Vol. L. **TABLE OF CONTENTS.** No. 9.

(20 pages; no inset.)

Page.

ENGINEERING NEWS OF THE WEEK 172

LEADING ARTICLES:

The 80-Ft. Concrete Arch Bridge Over the San Leandro Creek, San Leandro, California (illustrated) ..... Wm. B. Barber. 174

The Construction of the Simplon Tunnel.—III. (illustrated) 174

The Manufacture and Properties of Hydrate of Lime ..... S. Y. Brigham. 177

Infiltration of Ground Water Into Sewers ..... J. N. Hazlehurst. 179

A New Form of Friction Clutch (illustrated) ..... Prof. H. S. Hele-Shaw. 180

Sectional Electric Locomotives for the Baltimore Tunnel of the Baltimore & Ohio Ry. (illustrated) 185

The Standard and Its Use in Surveying (illustrated) ..... Edward Riordan. 185

The Efficiency of Concrete Mixing Machines (illustrated) ..... Clarence Coleman. 186

The Cathode Ray Alternating Current Wave Indicator (illustrated) ..... H. J. Ryan. 189

Cleaning a Large Brick Sewer in Hartford, Conn. ..... Frederick L. Ford 190

Use of Mineral Oil in Road Improvement ..... James W. Abbott 190

Concrete Water Supply Conduit at Los Angeles, Cal. (illustrated) ..... Wm. Mulholland. 192

EDITORIAL COMMENT.—Artistic Fire Hydrants—Infiltration of Ground Water Into Sewers—Improvement in Machine Shop Methods 182

EDITORIAL.—Methods of Macadam Construction in Northern New Jersey Towns 182

LETTERS TO THE EDITOR.—Suggested Standard Forms of Lettering Points on Transition Curves (illustrated): E. L. Hurley—"Balloon Construction" for Steel Skeleton Structures (illustrated): Louis L. Calvert—A Proposed Concrete Pavement: "Subscriber"—Joining Concrete Work Left Over Night: D. C. Jackson—The Construction of Skew Arches (illustrated): Geo. Jos. Bell 183

THE CORROSION OF METALS BY SEA WATER has been investigated by a German engineer named Diegel. Alloys of copper and nickel, with 20% and 42% of nickel, respectively, are not very rapidly corroded. They are rendered more or less immune by adjacent masses of iron, copper-alloys, or copper, these protectors being then more rapidly corroded. Copper-zinc alloys are corroded either by uniform solution of the alloy from the external surfaces, or, when the zinc exceeds about 24%, by a leaching out of the zinc, leaving behind a brittle and porous mass. This latter action is prevented, however, by the addition of 15% of nickel. Electrolytic copper, very pure, was rapidly corroded by sea water when in contact with ordinary impure (99%) copper. When not in contact the impure copper and electrolytic copper behave about alike. Annealed copper is much more rapidly corroded than rolled copper. Coating with zinc is a temporary protection, but after the coating is gone the corrosion of the copper is relatively rapid. Copper in metallic connection with iron is partly protected. Electrolytic copper whose surface was oxidized in places suffered rapid galvanic corrosion in the clean spots. The corrosion of copper pipes in vessels is often very rapid and occurs frequently at bronze joints. It seems that a high amount of arsenic (over 0.5%) in the metal greatly retards corrosion. Wrought-iron and steel of various methods of manufacture seems to depend for its corrosion upon the amount of phosphorus contained in it. With 1% of phosphorus present the corrosion was only a little over half as great as in the case of iron nearly free from phosphorus. When two pieces of iron differing in phosphorus-content were in metallic connection, the sea water corroded the low-phosphorus iron two to five times as fast as the other. Iron containing nickel showed similar behavior. The normal corrosion of single plates of material was less as the percentage of nickel increased, and when two plates differing in contained nickel were in contact, the plate higher in nickel was almost completely protected from corrosion. The normal corrosion of single plates, not in contact with other metal, suspended in the water of Kiel Harbor, is given in the following table, in grams per square decimeter per year:

	Grams.
Ingot iron. C = 0.05%, Mn = 0.44%, P = 0.07%	9.015
Copper, electrolytic, remelted	0.563
Bronze hammered. Cu = 95.6%, Sn = 3.5%, Fe = 0.5%, Mn = 0.3%	1.638
Bronze, cast, Cu = 89%, Sn = 11%	1.470
Bronze hammered, Cu = 57%, Zn = 42%, Fe = 0.5 to 1.0%	4.575
Aluminum bronze Cu = 91%, Al = 9.0%	0.000
Nickel-copper, 40% Ni	2.162
Nickel-copper, 20% Ni	1.848

These experiments are detailed in the Proceedings of the "Verein zur Beförderung des Gewerbefleisses," 1903.

BIDS FOR A SUCTION DREDGE for service in Savannah Harbor, Ga., are asked by Capt. J. C. Sanford, U. S. Engineer Corps, Philadelphia, Pa. The dredge called for is to have the following dimensions: Length between perpendiculars, 166 ft.; length over all, 177 ft.; beam, 38 ft.; depth, 19 ft. The frames are to be of bulb angles, spaced 24 ins. c. to c., and shall be in one piece from midship line to main deck plate stringer. All plating is to be worked "in and out" in longitudinal strakes. The hull is to be subdivded by watertight collision bulkheads on frames No. 9 and No. 73, extending to the lower deck only. A third bulkhead is to be placed on frame No. 41. Two coal bunkers are to be provided, one in each side of the boilers. The forward sand bin is to extend from frame No. 13 to frame No. 29; and the after bin from frame No. 52 to frame No. 58. The dredge will be propelled by two vertical, inverted, direct-acting, surface-condensing, fore-and-aft compound engines, with cylinders, of 15 and 30-in. diameter and common stroke of 24 ins. each, driving a 4-bladed cast-iron propeller of 7 ft. 6 ins. diameter and 12 ft. pitch. Steam is to be supplied by two Scotch return-tubular boilers, 13 ft. in diameter and 12 ft. long, fitted with three 40-in. corrugated furnaces each. There are to be two pumping engines of the vertical, inverted, compound, condensing type with cylinders of 12 and 22 ins. diameter and stroke of 14 ins. They are to be directly connected to the 15-in. sand pumps which are to be of the centrifugal type of extra heavy construction and especially adapted for dredging. The blades are to be covered with renewable steel plates for their entire working surface. The depth of the blade is to be uniform and to pass in easy curve from suction inlet to the periphery.

ELECTRIC SLEEPING AND PARLOR CARS for the Indianapolis & Eastern Electric Ry. are being built for the service between Indianapolis, Ind., and Columbus, O., about 190 miles. They will make the trip in one direction by day, and return at night. They are combination cars, with 20 revolving chairs when made up for day service, and 10 double-berth sleeping sections when made up for night service. Wooden flexible rolling partitions separate the sections, and also shut them off from the center aisle. A 2-ft. opening is left in the middle of the longitudinal partition of each section, and is fitted with a curtain. As the partition is 14 ins. from the sides of the berths there is more space for dressing and undressing than in Pullman cars, where the curtains forming the partitions are close against the sides of the berths. These electric cars are 48 ft. 3 ins. long over the end sills, 56 ft. 6¾ ins. over the platforms, 8 ft. 9¼ ins. wide over the sills, and 8 ft. 3½ ins. wide inside. At the front end are the motorman's room, porter's closet and women's toilet room. At the rear end are the smoking room, men's toilet room, and heater. The salon or main compartment is 34 ft. 2 ins. long, with a height of 6 ft. 5¾ ins. from floor to deck rail. The total height of the car above the rail is 13 ft. 4¾ ins. There are six comfortable sills, 7 × 7 ins., built of two timbers, with a ½-in. steel plate between. The car is mounted on two four-wheel trucks, 35 ft. 9 ins. c. to c., with 33-in. wheels and 7-ft. wheelbase. The fare will be $2 per berth or $3 for a section; this is in addition to the railway fare, which is about half that of the steam railways. When used as a parlor car the rate is $1 per seat. The patents on these cars are owned by the Holland Palace Car Co., of Indianapolis, Ind., and the cars are being built by the Hahan & Hollingsworth Co., Wilmington, Del.

A UNIFORM CLASSIFICATION of hours of lighting service is being requested by members of the National Electric Light Association. The following has been suggested by Mr. James Blake Cahoon, Secretary of the Association:

Schedule.	Hrs. per year.
Moonlight, midnight	1,220
" " 21 nights per month	1,260
" to 12:30 a. m.	1 387
" " 1 "	1 550
" " 2 "	1,890
" " 2 " 20 nights per month	1,680
Every night to midnight	1,825
" " 12:30 a. m.	2,000
" " 1 "	2,190
" " 3 "	2,920
Moonlight schedule and cloudy moonlight nights	2,250 to 3 200
Every night, 10 hours	3,650
Philadelphia schedule	3,680
All night and every-night	4,000

Obviously the classification is equally applicable to gas lighting.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the derailment of an excursion train on the Northern Pacific Ry., near Chehalis, Wash., on Aug. 22. Two men were killed and many others were injured. The derailment occurred on embankment, while the train was going at fair speed.—Nearly as bad was another accident, also a derailment, which occurred on the New York Central & Hudson River R. R., at Little Falls, N. Y., on Aug. 23. The Sunday morning newspaper train from New York ran around a bad curve at dangerous speed and jumped the track. The two enginemen were killed and several of the newspaper messengers were injured.

PROPOSALS FOR A WATER-WORKS FRANCHISE are wanted at Houston, Tex., on Sept. 14, as stated more fully elsewhere in this issue. Water is now supplied by the Houston Water Co. The value of the property of the company was recently fixed by appraisers at $1,081,222. A vote on issuing bonds for municipal ownership was taken on Aug. 4, and the proposition was defeated, but the total vote was very small.

MECHANICAL FILTRATION for the water supply of Harrisburg, Pa., has been recommended, after an investigation extending over some months, by Mr. James H. Fuertes, M. Am. Soc. C. E., of 140 Nassau St., New York City. The water supply will continue to be taken from the Susquehanna River.

A DAM FAILED AT MOUNT HOLLY, N. J., on Aug. 19. It was built across Upper Rancocas Creek, and was owned by the Public Service Corporation, which controls the local electric light plant. The power developed by the dam was used for general purposes, instead of for lighting. The dam appears to have been wholly or partly of timber, and not high.

A SMALL OUTBREAK OF TYPHOID FEVER at Lowell, Mass., is attributed to a temporary connection of the city mains with those leading from the reservoir of the Locks & Canal Co. The accident was attributed to the failure of a check valve designed to prevent such an occurrence. The number of cases of typhoid fever between Aug. 1 and 17 is reported as 24, compared with none in a similar period in 1902. The city water supply is taken from driven wells.

THE ILLINOIS & MICHIGAN CANAL may be utilized for the drainage of the Calumet region, instead of building a separate drainage canal to the Chicago drainage canal. This plan has been suggested by Mr. Lyman E. Cooley, M. Am. Soc. C. E., who estimates the cost at $2,500,000, as against $12,000,000 for the separate canal proposed by the Chicago Sanitary District. Mr. Cooley gives the population of the Calumet region as 100,000, while that of the North Shore district is about 2,000,000; the largest filth-producing industries are also in the main district and the North Shore district. He thinks therefore that provision should be made for disposing of more than twenty times as much sewage in the latter district as in the Calumet region, and that instead of spending $12,000,000 on the new Calumet drainage canal it would be better to spend the money in deepening the Chicago River and the North Branch, as the Illinois & Michigan Canal is capable of relieving the Calumet region for some years to come.

THE FRENCH LOCOMOTIVE for the Pennsylvania R. R., which was noted in our issue of Aug. 6, will be of the Atlantic type, with outside high-pressure cylinders driving the rear pair of driving wheels, and inside low-pressure cylinders driving the crank axle of the forward pair. The wheels will be connected by side or coupling rods in the usual way. The truck wheels have plate springs over the boxes, while the driving and trailing wheels have the springs beneath the boxes. The tender will be of the European six-wheel type, but with the two rear axles quite close together, the springs for these axles being connected by equalizers. All the tender springs are over the axle boxes. The boiler will be of the straight-top type, with short extension port. This engine will be built by the Societe Alsacienne des Constructions Mecaniques, at Belfort, and its leading dimensions will be as follows:

Driving wheels	6 ft. 8½ ins.
Truck wheels	3 " 2 "
Trailing wheels	3 " 6¾ "
Tender wheels	4 " 1 "
Wheelbase, driving,	7 " 3 "
" engine	28 " 6 "
" tender	15 " 5 "
Weight on driving wheels	83,600 lbs.
" " truck	44,000 "
" " trailing wheels	33,000 "
" of engine in working order	160,600 "
" " tender, empty	41,800 "
" " tender, loaded	100,200 "
" " water in boiler and fuel on grate	13,200 "
Cylinders, h.-p., (2)	14 3-16 × 25 3-16 ins.
Cylinders, l.-p., (2)	23¾ × 25 3-16 "
Boiler, straight-top, diameter	4 ft. 11¼ ins.
Boiler pressure	227 lbs.
Tubes, Serve ribbed	189
Tubes, diameter inside, 2 9-16 ins.; length	14 ft. 5¾ ins.
Heating surface, tubes	2,435.7 sq. ft.
" " firebox	181.1 "
" " total	2,616 8 "
Grate area	33.9 "
Length of tender	25 ft. 3 ins.
Coal on tender	12,300 lbs.
ater in tank	46,200 "

THE 80-FT. CONCRETE-ARCH BRIDGE OVER THE SAN LEANDRO CREEK, SAN LEANDRO, CAL.

By William B. Barber.*

The accompanying illustrations show a concrete arch bridge which is rather interesting because of its span of 81¼ ft. built of un-reinforced concrete. This bridge crosses San Leandro Creek on the line of the county road between Oakland and San Leandro, Cal. Fig. 1 is a view of the completed

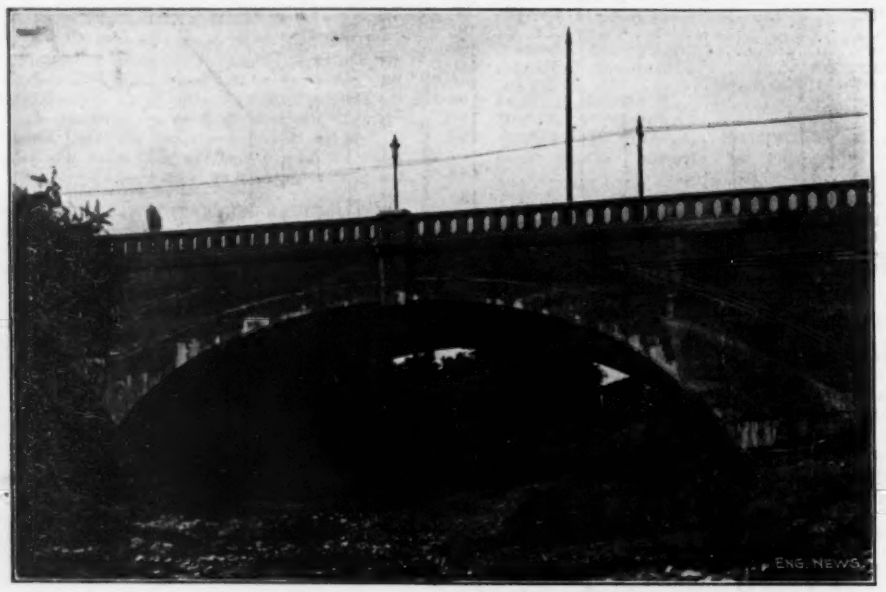


FIG. 1. CONCRETE ARCH BRIDGE OF 81-FT. SPAN NEAR SAN LEANDRO, CAL.

bridge, and Fig. 2 shows the center and some of the dimensions of the arch ring.

The bridge is a monolithic structure, built entirely of concrete, and its total length is 192 ft. No iron whatever was used in the construction of any of the parts of the bridge. It is a five-centered, elliptical arch, with a rise of 26 ft., and a span of 81 ft. 3 ins.; the arch has a 10° skew from a right angle and its thickness at the keystone is 3 ft. The centers as shown by the original plans were intended to rest upon sand boxes, but in the construction of the bridge wedges were substituted and were found to work very successfully.

About two miles up the stream from the location of the bridge is a dam that impounds the water supply for the city of Oakland. During the time of the construction of the bridge very little water was in the creek, but after the footings had been set and the haunches had been built about one-third the way up on each side, the filters at the dam were cleaned and the construction work flooded. The wedges under the centerings were flooded and the ground softened. In order to make the arch self-sustaining and to allow it to carry the extra weight that was to follow, a ring of the concrete, 1 ft. in thickness, was built up and keyed. Work was then continued upon the haunches and the arch was built upon the inner ring to its full thickness, as shown in the plan. Thus it will be seen that the arch is really built of two distinct rings.

The arch spans a waterway having a total area of 1,650 sq. ft. The footings of the arch have a width of 30 ft. on each side and extend 5 ft. below the bed of the creek, resting upon a bed of clay which is slightly interspersed with gravel; the footings rest on the original clay without piles. After the second arch ring had been keyed and the fill nearly completed, a 3-ft. water main that supplies the city of Oakland burst, and, cutting its way around the south end of the bridge, flooded the arch and removed a large portion of the fill. This had no effect upon the stability of the arch.

The centers were struck ten days after the keying of the second arch ring and the settling at the crown of the arch did not exceed 1½ ins. The main retaining walls for the approach are built also of concrete and have a length of 90 ft.

The total amount of concrete used in the bridge was 3,384 cu. yds. Scales' brand of Portland cement was used in the footings, while above the haunches and in the crown of the arch, Alsen brand was used. The concrete mixture consisted of 7 barrels of rock of varying sizes, 2 barrels of sand, and 1 barrel of Portland cement. Two winters were allowed to pass in order to allow the fill over the arch to properly settle; and the contracts have been let for the construction of a macadam roadway, 41 ft. wide, over the bridge and cement walks, 8 ft. wide, on each side; a granite curbing, 10 ins. in width, separates the walks from the roadway. On each side of the bridge is a parapet wall, 3 ft. 6 ins. in height.

There were 90,000 ft. of lumber in the forms used in the construction of this bridge. The finish of the exposed surface did not receive a coat of plaster, surfaced lumber being used next to the face of the bridge. It was built in 1901 from plans prepared by the County Surveyor's Office of Alameda County, California, and the construction was under the superintendency of the same office. The bridge was constructed by the E. B. & A. L. Stone Co., of Oakland, whose contract price was $25,840.

*1492 High St., Alameda, Cal.

THE CONSTRUCTION OF THE SIMPLON TUNNEL.

III.

Methods of Construction.

A brief general description of the Simplon Tunnel was given in the first article of this series. To understand clearly the details of the methods of construction, however, some further account of the tunnel structure is necessary. This structure extends from a place called Baffi, a few miles from Brieg on the River Rhone to a point near the village of Iselle in Italy. The distance between portals is 19,729 m. (12.4 miles). The alinement is straight except for a short curve at each end. The curve at the Swiss end turns to the northwest and has a radius of 250 m. (820 ft.), or is a 7° curve, and that at the Italian end turns to the east and has a radius of 450 m. (1,476 ft.), or is a 3° 53′ curve. The elevation of the Swiss portal is 2,250 ft. and that of the Italian portal is 2,076 ft. The highest point of the tunnel is a level stretch of 500 m. (1,640 ft.) at an elevation of 2,310 ft., located about midway between portals. From this summit level the line descends on a 0.2% grade to Brieg and on a 0.7% grade to Iselle. The foregoing are the longitudinal characteristics of the tunnel.

Transversely the tunnel consists of twin single track tunnels exactly parallel in plan and profile. These parallel tunnels are spaced 17 m. (55.76 ft.) apart, c. to c., and are planned to be identical in sectional profile. The adopted profiles for the different materials are shown by the drawings of Fig. 1. At the summit level the cross-section is increased in dimensions to accommodate two tracks. At present only one of the twin tunnels is being constructed to its full dimensions; the other is being opened by a small gallery which serves for drainage, ventilation and other services connected with the tunnel work. These characteristics are clearly indicated by the drawings of Fig. 1. At intervals of about 200 m. (656 ft.) the service gallery and the tunnel are connected by transverse galleries, as shown by the partial plan, Fig. 2. The uniform distance apart of these cross-galleries has been interfered with at a few points where special conditions demanded changes in the adopted plans, but normally they were constructed as shown by Fig. 2 and were spaced 200 m. apart.

The tunnel is lined throughout with masonry, the cross-section of the lining masonry varying with the character of the material penetrated, as shown by Fig. 1. The normal section of the lining is interrupted at intervals by niches and side chambers. These are of three forms. At every 100th meter there is a small refuge niche of the construction, shown by Fig. 3; at every kilometer (0.62 mile) there is a small chamber constructed as shown by Fig. 4, and every four or five kilometers there is a large chamber constructed as shown by Fig. 5. It will be observed that these large chambers are designed to penetrate from tunnel to tunnel, when the second tunnel is developed to its full section. In conclusion it should perhaps be noted that the tunnel masonry terminates at each end in a portal of architectural design.

ALINEMENT.

To describe in detail the method of fixing the center line of the Simplon Tunnel would involve a description of special surveying operations which would run into great length, and we shall, therefore, simply outline the general plan of operations. These comprised the usual location of the surface axis and terminals and the establishing of reference points from which the axis could be transferred underground, and also the usual

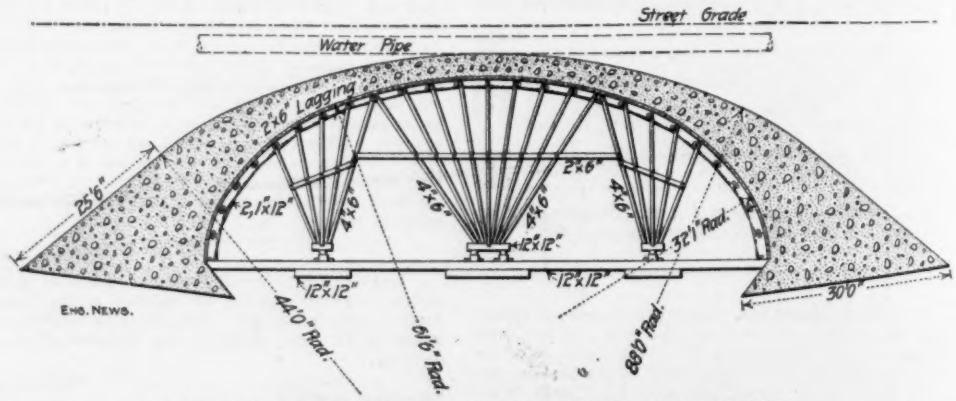


FIG. 2. CENTER FOR SAN LEANDRO CONCRETE ARCH BRIDGE.

periodical surveys by which the underground workings were directed. A preliminary surface survey of the tunnel line was made in 1898 and in 1899 the line was finally and carefully located by a system of triangulation connecting onto the Main Swiss triangulation system. This survey gave the engineers the necessary reference points at each end of the tunnel from which the surface axis could be carried underground. The daily

direction of the work underground involved no unusual features. A verification of the underground line is made each month, every three months and once a year, using separate sets of instruments for each of the surveys. The quarterly verifications are made with particular care,

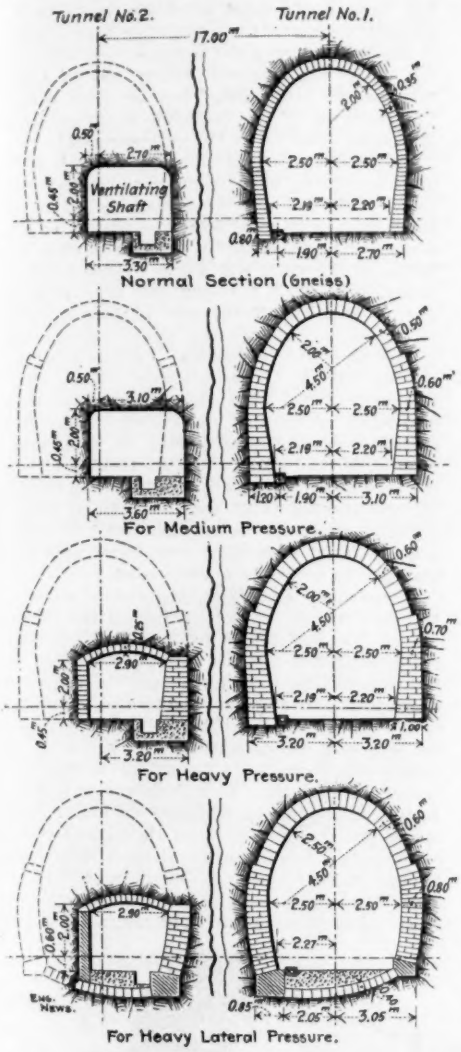


Fig. 1. Standard Sections of Simplon Tunnel in Different Kinds of Material.

and at the time of the annual verification, which is made on December 4, or the anniversary of Santa Barbara, all work is stopped and the tunnel is cleared and specially ventilated for the surveying operations. The fixed points in the tunnel are located every 100 m. (328 ft.) or 200 m. (656 ft.) and are marked during surveying operations by acetylene lamps.

NORMAL METHODS OF EXCAVATION.

The methods adopted for excavating the Simplon Tunnel can be divided into (1) the method normally followed and (2) a modification of this method, which is employed on certain difficult sections of the work. It may be premised further that the specific methods described are those followed at the Italian end of the work. The work at the Swiss end is, however, carried on in a much similar manner.

SEQUENCE OF EXCAVATION.—The sequence of excavation followed in taking out the tunnel section is shown diagrammatrically by Fig. 6. The center bottom drift No. 7 is first driven by means of power drills and is then timbered and covered with a closely boarded roof. From this drift a shaft is driven upward to the roof line every 50 m. (164 ft.). The top heading No. 2 is then excavated by working in both directions from each of these shafts. Next in order is the removal of the shallow transverse section No. 3 and then the two side cheeks No. 4. It will be observed that no disturbance of the timbered drift No. 1 occurs during the excavation of part No. 2 and No. 3, so that traffic through the drift goes on uninterruptedly.

POWER DRILLING OPERATIONS.—The advance drift No. 1 is the only part of the excavation performed by power drills. The drills employed are Brandt rotary drills, the construction and mounting of which are shown by Figs. 7 and 8. The feed of the rotary cutting tool is accomplished by the direct pressure of water in a large cylinder, the piston of which returns automatically when the water supply is cut off. The mandril carrying the boring bar and also the cutter are driven by means of two cylinders located above the feed-cylinder. These cylinders operate a shaft having a worm gear which meshes with a worm wheel centered on the mandril. The cylinders are 1⅞ ins. in diameter and their pistons have a stroke of 2¾ ins. They are operated by hydraulic pressure and each uses normally 1 liter of water per second. The two cylinders are connected by cross water ways and the piston of one acts as the valve of the other. The speed of the cutter necessarily varies for different densities of rock, but its highest speed is ten revolutions per minute. The drill as described is mounted in groups of two or more on a heavy iron thrust bar about 12 ins. in diameter. This thrust bar is pivoted to the drill carriage and is counterbalanced, as shown by Fig. 8. It will be clear of course that all holes bored by the drill must radiate in direction from the transverse thrust bar as an axis.

In the Simplon Tunnel work the drills are mounted in groups of three, and one carriage is worked in each heading. Normally there are two headings in progress, namely the advance drift No. 1 in the tunnel and the service gallery. At times two headings have been worked in the tunnel, making three sets of drills and nine boring heads in operation. The hollow head or cutter is 3 ins. in outside diameter and has a bore 1½ ins. in diameter. The depth of the hole bored is usually 4½ ft., and different lengths of boring bars are employed to suit the more or less worn up condition of the cutter head. This is attached to the boring bar by a one-quarter turn of a square quadruple threaded screw. The number of spare heads employed is considerable, there being 24 allotted to the Italian end of the work.

In normal operation the work proceeds as follows: The thrust beam is wedged between the two side walls of the heading by means of timber blocking. The holes are then started by means of a V-shaped center bit, each hole being located with due regard to the rock seams and stratification and so as to obtain the best blasting effect possible. After the holes have been started the center bits are replaced by the rotary cutters. The time taken to bore one hole varies considerably, but it may be estimated from the daily advance made, which is given below. Ordinarily ten or eleven holes are bored. The section at the heading is nominally 6½ × 9½ ft., or 61¾ sq. ft., and as the depth of each blast is roughly 4½ ft., the cubic content removed with each blast is from 265 to 275 cu. ft. During the early stages of the work and again recently the number of blasts amounted to only four or five per day, and the average daily advance for the month was about 16 ft. at the Italian end and from 20 to 21 ft. at the Swiss end. This work was in a gneiss rock. In rock of a more friable nature, such as the anhydrite or lime sulphate, an advance of as much as 34 ft. has been made in 24 hours. After each blast the time required to clear the heading, set the drills, complete the boring and remove the drill carriage to a point of safety is upwards of an hour.

The cutter is aided in its work by the water discharged into its interior from the cylinders. This

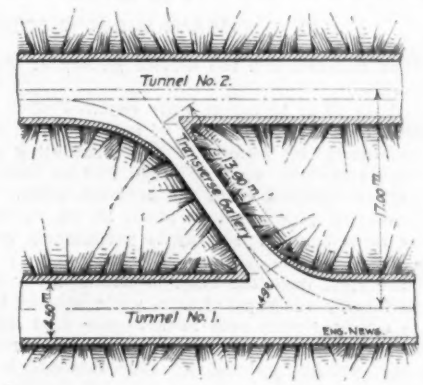


Fig. 2. Plan of Portion of Twin Tunnels Showing Cross Gallery.

water emerges from the drill hole around the outside of the cutter and carries with it the borings in the form of a coarse powder. The cutter teeth are set with a clearance of about ¼-in., so that the hole bored is 3½ ins. in diameter or ½-in. larger than the cutter cylinder. This amount of clearance is ample to keep the cutter from binding and to permit the drill hole to be readily freed from all borings. When desired the water may be discharged direct from the cylinders without entering the cutter. Except in the very hardest rock no core is formed by the drill.

EXPLOSIVES.—The explosives used are dynamite at the Italian end and blasting gelatine at the Swiss end. The following are the compositions of these two materials:

	Dynamite.	Gelatine.
Nitroglycerine	83%	64%
Octomitric cotton	5%	3%
Potassium nitrate	10%	..
Cellulose	2%	8%
Soda nitrate	..	24%
Carbonate of magnesia	..	1%
Total	100%	100%

At the Italian end the dynamite storage house is located at Varzo, about 1½ miles from the tunnel portal, and each day's supply is taken from here and transported on a push car to a storehouse located in one of the cross galleries of the workings.

MINING OPERATIONS.—The dynamite is put up in ½-kg. (1-lb.) packages, and each hole is

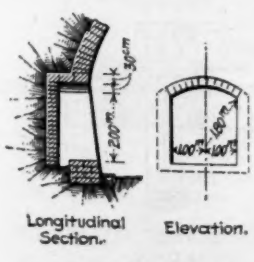


Fig. 3. Details of Small Niches Spaced 100 m. Apart.

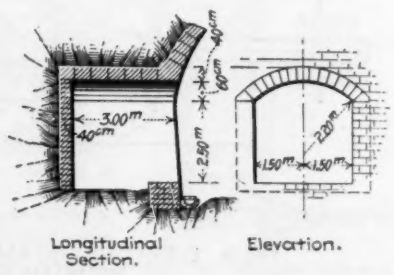


Fig. 4. Details of Large Niches Spaced 1,000 m. Apart.

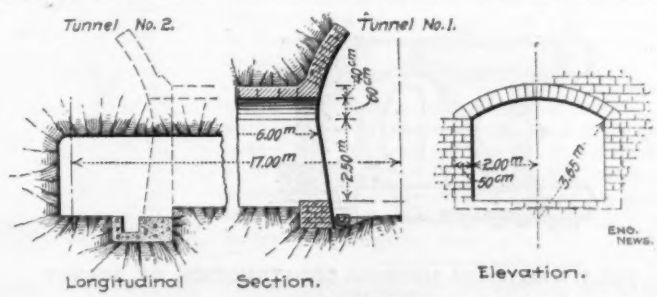
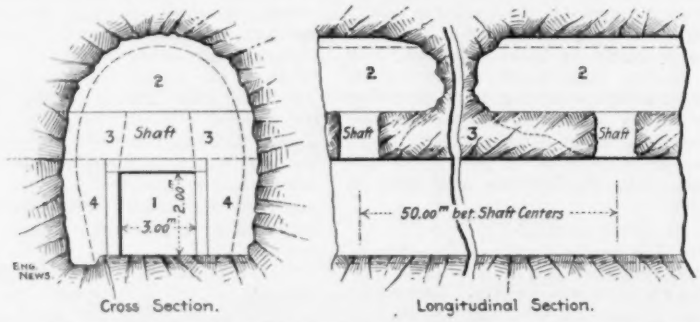


FIG. 5. DETAILS OF LATERAL CHAMBERS SPACED FROM 4,000 to 5,000 m. APART.

charged with six packages. Each blast, therefore, represents from 60 to 66 lbs. of explosive. The charges are fired by means of ordinary fuses, which are so cut as to give a half-minute interval between the firing of successive holes. The blast frequently throws the fragments of rock to some distance, and all machinery which can be removed, as well as the men, takes refuge in the



Cross Section. Longitudinal Section.

FIG. 6. DIAGRAM SHOWING SEQUENCE OF EXCAVATION IN SIMPLON TUNNEL.

cross galleries and the service gallery of Tunnel No. II.

About 10 or 15 minutes are required after each blast to clear the heading of fumes. This is accomplished by means of the ventilating pipe, which runs close up to the fuse, and by means of a spray operated from the pressure pipes. The ventilating pipe exhausts about 35 cu. ft. of air per second, and the spray is particularly useful in absorbing the sulphurous gases.

The spoil from the blast is cleared away from the face by one gang of men, while another loads the collected rock onto narrow-gage cars hauled by horses. No tools are used, all the material being handled by manual labor alone. Every effort is made to rush this work of clearing the heading so that the drills may be got back to work as soon as possible. To this end the clearing gangs are composed of men who have been previously rested by performing light work only, and only the most skilled and energetic laborers are employed. The majority of the laborers are southern Italians, both at the Italian and the Swiss ends. Some Swiss and a few Prussians are employed, but mostly in connection with the machine work. There are 14 or 15 men at each heading and they are worked in three shifts daily. Each gang has two horses for each shift. These are supplied by a local peasant job master at $1.60 per day, and each horse works eight hours a day, with an occasional day's rest. The horses die off quite rapidly, and each death is paid for by the tunnel contractors. Various other methods of transportation have been considered and a few others have been experimented with, but none have appeared to the engineers to offer any economy over horses for transportation in the advance heading. The horses take the cars to compressed-air locomotives and these in turn take them to steam locomotives, as described in the second article of this series.

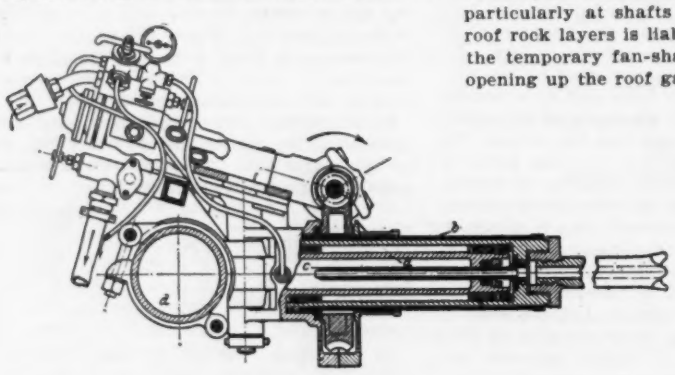


FIG. 7. SECTIONS SHOWING CONSTRUCTION OF BRANDT ROTARY DRILL.

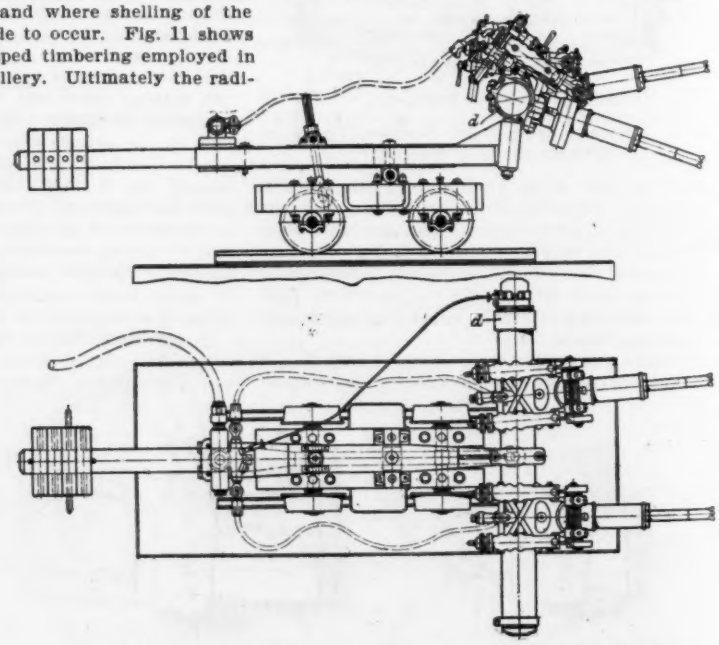


FIG. 8. ELEVATION AND PLAN OF BRANDT ROTARY DRILL MOUNTED FOR OPERATION.

TIMBERING.—The timbering of the tunnel excavation comprises first the timbering of the bottom advance drift; second, the timbering of the vertical shafts, and, third, the timbering of the top heading and the enlargements. All portions of the work are timbered. The timber ordinarily and generally used for timbering at the Italian end is birch and fir cut from the mountain slopes above Iselle and conveyed to the tunnel entrance by wire rope-ways. The amount of timber used is large and a considerable force of lumbermen is kept steadily at work by the contractors.

The timbering of the bottom drift or advance gallery consists of quadrangular frames set at intervals and carrying a longitudinal lagging on their caps. The side posts are sometimes vertical and sometimes have a slight batter, and the frames are with or without sills, according to the transverse lay of the rock seams. The several drawings, Figs. 9 to 11, inclusive, all indicate quite clearly the nature of the advance gallery timbering. These drawings show various designs of the full section timbering used. The form shown by Fig. 9 is the one preferred when it can be used, but that shown by Fig 10 is much used, particularly at shafts and where shelling of the roof rock layers is liable to occur. Fig. 11 shows the temporary fan-shaped timbering employed in opening up the roof gallery. Ultimately the radiating struts B, C and D are replaced by the full section members A′, B′, C′ and D′ as the excavation is developed. In the full section timbering the transverse frames are spaced 8 ft. and 10 ft. apart and sometimes even greater distances, depending upon the nature of the rock penetrated.

LINING.—The tunnel is lined with coursed masonry from end to end, and the character of the masonry at different points is shown by the standard sections of Fig. 1. Figs. 3, 4 and 5 show the masonry work of the niches and side chambers. The facing stone of all this masonry is antigorio gneiss at the Italian end. Under normal conditions the lining is built as fast as the enlargement of the section is completed, but where water has been encountered or where the rock is of unstable character there has often been a distance of 1,300 ft. between the completed side walls and the end of the enlarged section, and of 1,600 ft. between the latter point and the arch masonry. The endeavor of the engineers is always to keep the lining close up to the enlargement.

The method of constructing the lining is to build the sidewalls up to the springing lines and then to follow with the roof arch masonry. The walls being built, a vertical frame, composed of a cap, a sill and posts, is set up as close to each as the batter of the walls will allow. These frames are about 10 m. (32.8 ft.) long and are indicated at A A in Fig. 12. Transverse timbers are placed so as to span across the space between these frames and carry a flooring. On this flooring are set the ribs for the arch center. These ribs are composed of two 7-in. I-beams bent edgewise and connected by bolts at the crown. They are adjusted to elevation by means of wedges under their ends, and carry a timber lagging on which the arch masonry rests. As will be seen from Fig. 12, the staging is of such dimensions that the material cars pass freely underneath it, and the arch material is hoisted from these cars to the platform by means of a chain hoist.

Where there is a strong discharge of water from the roof rock it is diverted during the construction of the arch ring by means of metal shields or plates set below the roof poling boards, and when the ring has been completed and the brick filling is being placed a channel is formed in the latter to take the water down behind the arch ring and the side wall, through the foot of which is a passage to the main drain formed in the floor of the tunnel at one side. This drainway is formed in hydraulic cement, as indicated by Fig. 12, which shows the spring located on the haunch opposite to the tunnel drain, thus requiring a cross passage in the tunnel floor. In some instances where there has been a small leak in the roof rock it has been connected with a ½-in. or ¾-in. pipe led down through the filling and arch ring and then carried down the soffit and side wall, as shown by Fig. 12.

The thickness of the arch ring varies from 14 ins. in solid rock to 20 ins. and 24 ins. in friable rock; in exceptional cases, such as are noted further on, the arch ring has been made upward of 4 ft. thick. The filling above the arch ring is

cemented rubble and it amounts to about 3 cu. ft. per lineal foot of tunnel.

MATERIALS PENETRATED AT ITALIAN END.—It will be remembered that the working entrances at the Italian end are on the line of the tunnel tangent extended. The short curve which will form the actual tunnel will be excavated toward the conclusion of the work. Practically this same method of opening up the work is followed at the Swiss end. The materials penetrated, beginning at the working entrances at the Italian end, have been as follows: At the entrance there was a mere crust of ferrous quartz. This was followed for a distance of 4,350 m. (14,268 ft.) by a very hard gneiss, lying in horizontal strata and known as antigorio. This gneiss contained occasional seams of crystalline rock, quartz, sulphur, pyritis, etc. From meter 4,350 to meter 4,450 the material was calcareous rock and green mottled cipolin. Previous to the ending of the gneiss rock, however, water was encountered, as described in the second article of this series. Beyond the cipolin, for about 40 m. (131.2 ft.), or from meter 4,450 to meter 4,490, a disintegrated slate clay was encountered, which proved to be a most treacherous material and which has up to the present time been the most difficult part of the whole tunnel. The method of penetrating this disintegrated rock is described in a succeeding section. Succeeding the disintegrated slate there were about 60 m. (196.8 ft.)

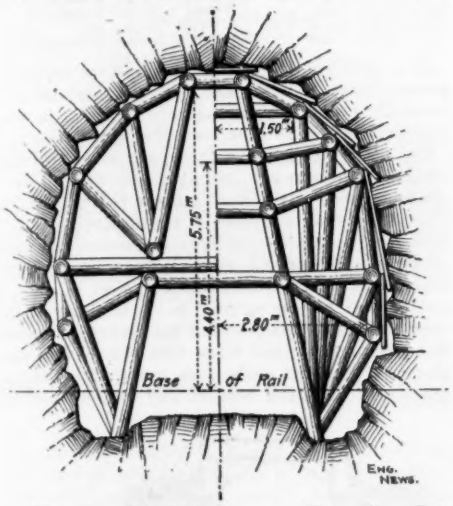


Fig. 9. Standard Form of Timbering for Simplon Tunnel.

Fig. 10. Extra Heavy Form of Timbering for Simplon Tunnel.

of a jumbled mixture of micaschist, schistic-gneiss, cipolin, quartz and white marble. From meter 4,550 to meter 4,850 the rock was anhydrite or crystalline sulphate of lime. Then followed calcareous rock, schists, anhydrite, granitoid rocks and schistic gneiss, the last being nearly as dense and hard as the antigorio first encountered. All these rocks were in horizontal strata. These conclude the list of materials so far penetrated.

As already described, the method of penetrating the materials described was to open an advance bottom drift by means of power drills, then to project upwards shafts at intervals and to extend a top heading from each of them, and finally to enlarge this heading and open up the full profile. This enlargement was all accomplished by hand drilling and blasting. Normally this method of excavation has proved satisfactory, but when the disintegrated slate was struck it failed entirely, and another and special method had to be devised for carrying on the work. This method will now be described so far as it has been developed.

METHODS OF EXCAVATING THROUGH DISINTEGRATED ROCK.

The disintegrated slate clay was a water-soaked coarse powder absolutely without stability. It was penetrated by first opening a bottom drift and then enlarging this drift and erecting the lining. This was of unusually heavy section, and is shown by Fig. 13. At first it was attempted to proceed by using the ordinary timbering methods with timbers of unusual strength, but the crushing of this timber soon put a stop to the task. First one thing then another was tried in the way of special timbering, but all of them failed, and no success was had until a combination method of steel and timber strutting was employed. This is shown in the succeeding illustrations, Figs. 14 to 17.

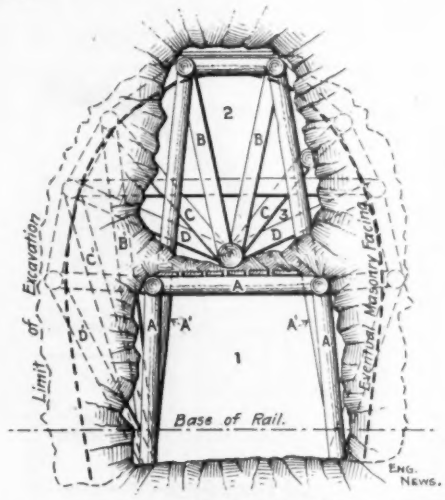


Fig. 11. Progressive Stages in Arch Timbering During Enlargement.

ADVANCE DRIFT.—The advance drift was excavated by opening first a 5 × 5½ ft. drift near the bottom and timbering it with rectangular frames sheeted with poling boards on all four sides. This small drift was then enlarged by taking out a heading above it and working down the sides. In the enlarged section a lining composed of special I-beam and timber frames was then placed. Beyond the general statement given it is not possible to describe the mode of operation. The excavation and timbering was done piecemeal by scraping away a bit at a time and keeping the faces supported by lagging and struts placed as demanded and as would but serve the immediate purpose. The final I-beam and timber lining was erected by first placing the sill, then erecting the cap and finally wedging in the wall posts. The construction of these lining frames is shown by Fig. 14. In the most difficult portions the frames are set close together, as illustrated, so as to form a tight lining, but in more stable material they were spaced varying distances apart and filled between with concrete. Each frame weighed 2,640 lbs., and altogether 74 were erected. The cost of this timbering was about $4,400 per meter.

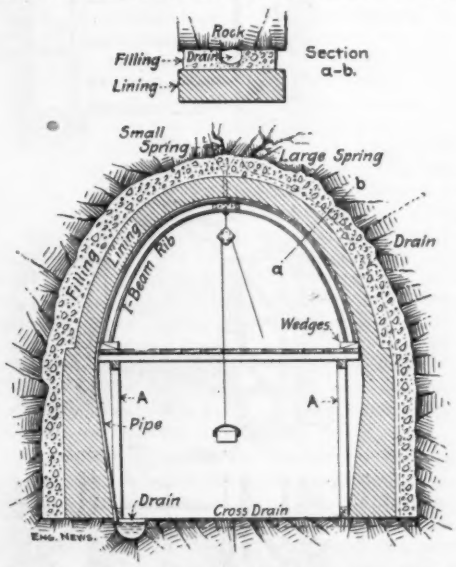


Fig. 12. Diagram Showing Method of Constructing Lining.

ENLARGEMENT OF SECTION.—The method of enlarging the drift which was timbered by the I-beam and timber frames is illustrated by Figs. 15 and 16, inclusive. Work is started by chopping out the timbers between a pair of the steel wall beams at a height convenient for the passage of men and materials, as shown at B, Fig. 15. This opening is framed with a square cap and sill and vertical side posts, leaving a clear opening 0.9 m. (2.9 ft.) high and of a width equal to the distance between the iron frames less the thickness of the side posts. Excavation is begun horizontally outward from each opening until a space 4 ft. deep and 4 ft. 8 ins. high has been excavated and timbered and sheeted, as shown by Fig. 15 B, "1st stage." The timbers used are round in cross-section and of the dimensions shown by the drawings in centimeters. This opening is simultaneously carried downward, as shown by the several stages of Fig. 15 B and C, and laterally until it has a width of about 9 ft. 10 ins., as shown by the plan Fig 15 A. The work is now ready for underpinning the steel frame. The first operation is the insertion of a longitudinal 8 × 12-in. timber under the corners of the frames, as shown in Fig. 15 B "2d stage." Under this beam four 12-in. wood posts are inserted in local cavities excavated for them, as shown by Fig. 15 C "4th stage." These posts stand on a floor plate, as shown by Fig. 15 D "5th stage," and the whole frame is braced laterally against the wall and floor timbers, as shown. The next operation is to place a second frame of cap, posts and floor plate further under the frames. These operations proceed simultaneously from both sides until the underpinning is completed, as shown by Fig. 15 D and E.

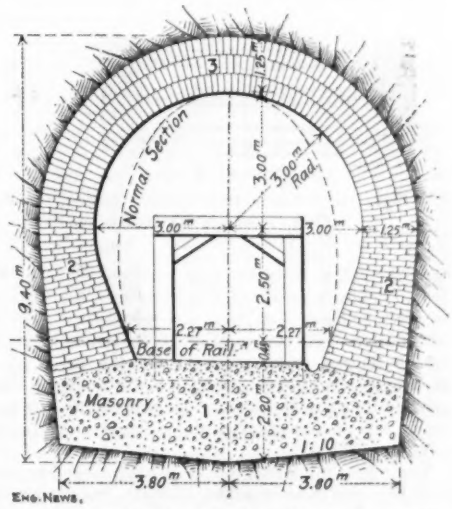


Fig. 13. Lining Used for Very Heavy Pressures.

The next step is to build the center portion of the masonry floor, as shown at Fig. 16 F. Lateral extensions of the excavation for the side walls are then made and timbered, as shown by Fig. 16 G. Side wall construction is then begun and carried upward, as shown by Fig. 16 H and I, until the springing line of the arch is reached. The work described is conducted from a number of openings at once, and are then connected by breaking down the ends of the section in both directions until the excavations and masonry meet. The method of enlargement for the construction of the roof arch has not been finally worked out, but a plan which has met with favor is to fill in the space 1, Fig. 17, with temporary masonry and then construct the temporary masonry arch 2 as a center upon which to construct the permanent arch.

THE MANUFACTURE AND PROPERTIES OF HYDRATE OF LIME.

By S. Y. Brigham.*

Probably the most important development in the lime industry during the past ten years, and one which is effecting every manufacturer, whether he is conscious of it or not, is the rapidly increasing production of hydrate of lime as a substitute for quick lime.

*Toledo Southeastern Ry. Co., Toledo, O.

Hydrate has been manufactured for many years, both in this country and in Europe, but on account of the crude methods by which it has been produced, it has never until now really answered all purposes served by quick lime. Furthermore, it has always been an expensive material to produce, and probably one of the important factors in the present rapid development is the confidence that the manufacturers have in their ability to compete with other forms of lime in cost of production.

The first hydrate to be put on the market in large quantities (excepting high-priced finishes)

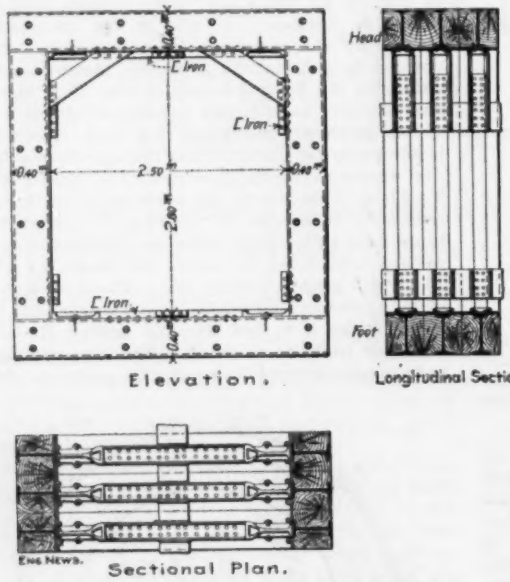


Fig. 14. I-Beam and Timber Lining for Advance Drift Through Disintegrated Rock.

was the 'New Process" lime manufactured in Toledo. This was a very fair article and served many purposes, but the care necessary for its production, and the comparatively crude plant at which it was first made, forced the price to a point considerably higher than the price of lime, and limited the demand. The same article is now being put on the market under much more favorable conditions.

The advantages offered by a first-class hydrate, and the enormous market in sight, providing the barrier of excessive cost could be overcome, induced Mr. H. P. Dodge, of Toledo, O., to carry on a series of experiments which culminated in the erection of an experimental plant. This process has proved to be entirely successful, and has been adopted by most of the larger plants making hydrate, including The Rockland-Rockport Lime Co.; Kelley Island Lime & Transport Co.; Charles Warner Co.; J. B. Speed & Co.; The Toledo White Lime Co., and others.

It is the intention, in this article, to deal with the method of manufacture; to show the results of comparative tests, and to make a general comparison between the qualities of quick lime in the lump form and hydrate.

As is well known, there are two distinct forms of lime—the rich lime, high in calcium, and the magnesium lime, burned from dolomite. The principal defects in both forms can be summed up as follows: (1) They deteriorate rapidly; (2) They cannot be kept in packages for any length of time; (3) they are dangerous to store on account of fire; (4) they require manipulation before using, i. e., slacking, screening, ageing; (5) they invariably contain small particles which swell after being on the wall a few months, and spoil decorations; (6) they cannot be transported safely by water; (7) they are difficult and dirty to handle.

To be brief, proper hydration does away with everyone of these defects, without impairing the usefulness of the lime. Probably the greatest future of hydrate of lime lies in its use with Portland cement, which will be dealt with later.

Various methods of manufacturing hydrate have been patented in this country and abroad. The most successful method in this country is as follows: The lump lime as it comes from the kilns is finely ground and passed over a 26 mesh wire screen. It is then elevated, and dropped into a digestor and treated with water at a certain temperature; the two being handled in such a way that the lime cannot possibly burn. This mixture is then cooled and screened through an extremely fine silk screen, and all particles not thoroughly hydrated are taken out.

The powder is then put up in paper and jute

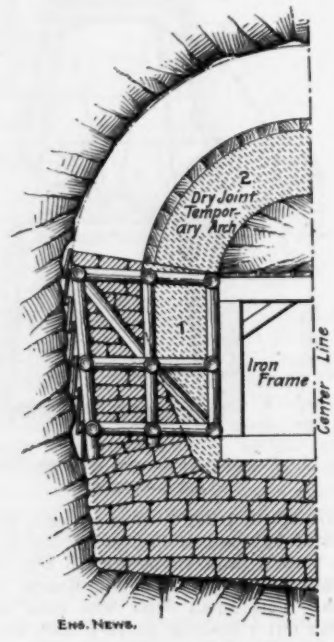


Fig. 17. Suggested Method for Building Roof Arch Through Disintegrated Rock.

sacks and can be kept indefinitely. The process is extremely simple, but contains several fine points which have been carefully developed, and which, if not properly attended to, will cause the product to work short or "tough" under the trowel.

Both the rich and the magnesium limes can be hydrated, but a very peculiar condition is encountered in the hydration of the latter. It is well known that Mg O does not swell when forming its hydrate, and but little heat is evolved. It is found by analysis that the hydrate produced from dolomitic lime contains only enough water to satisfy the Ca O present, which would indicate almost conclusively that the Mg O remains unchanged and what we really have is the mixture of calcium hydrate and magnesium oxide.

This is not only true of the dry hydrate, but of all lime putty made from dolomitic lime, and doubtless accounts for the inability of the slow-working magnesium lime to carry as much sand as rich limes which is a fact well known by all practical mechanics.

The amount of water added to produce complete hydration, varies therefore with the amount of calcium oxide present in the quick-lime. Where the analysis is very pure, say 97% Ca O, it requires the addition of 55 lbs. of water to 100 lbs. of lime. In pure dolomitic limes, only 36 lbs. water to 100 lbs. of lime is required. One hundred pounds rich lime and 55 lbs. water will produce 135 lbs. of hydrate, while 100 lbs. of magnesium lime and 36 lbs. of water produce only 123 lbs. of hydrate. For brick laying, prepared mortar, mixing with cement, etc., it is evident that the strong or rich limes have the advantage over their whiter competitors, but it is probable that the magnesium lime, in the form of hydrate, would still excell for finishing purposes.

Test for tensile strength of hydrate as compared with quick lime have shown very satisfactory results:

Hydrate (Dodge process)	3 days,	15 lbs.	2 weeks, 80 lbs.
Hydrate (wet process)	2 days,	5 lbs.	4 weeks, 35 lbs.
Rich quick lime	3 days,	18 lbs.	3 weeks, 50 lbs.
Magnesium quick lime	2 weeks,	30 lbs.	3½ " 90 lbs.
Air slacked lime	1 day,	7 lbs.	3 weeks, 11 lbs.

It is well known that all lime mortar gradually grows harder with age, as the carbonate is formed; this rule applying to mortar made from hydrate as well as that made from quick lime.

The effect of adding a little hydrate to Portland cement is somewhat astonishing. Careful tests made by one of the best cement chemists in the United States show that a mixture of cement 1, hydrate ¼, sand 4, is nearly one-half stronger than cement 1, sand 4 without lime. Nearly equal results are given with cement 1, lime ¼, sand 5, and cement 1, lime ½, sand 5. It is also probable that the mortar containing the hydrate is much less porous than that made with cement and sand alone. The above tests were made with the best quality of Portland cement and may be counted upon as reliable. Tests were made showing that cement 1, sand 4 showed 260 lbs. at 7 days, while cement 1, lime ¼ and sand 4 showed 340 lbs.

On the other hand, the addition of a little Portland cement to a large amount of hydrate does not show gratifying results.

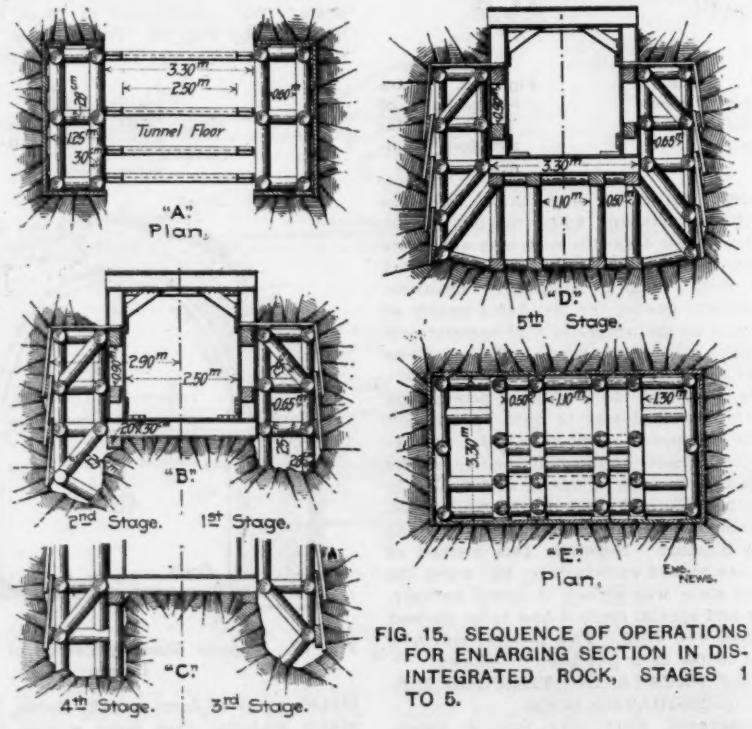


FIG. 15. SEQUENCE OF OPERATIONS FOR ENLARGING SECTION IN DISINTEGRATED ROCK, STAGES 1 TO 5.

The following table explains itself:

					14 days.	28 days.
Hydrate	160,	cement	0,	sand	480. 70 lbs.	43 lbs.
"	120,	"	40,	"	480. 110-114 "	96-103 "
"	80,	"	80,	"	480. 311-327 "	252-258 "

In all of the above cases the results at 28 days were lower than at 14 days, although it is probable that they would improve again after a longer time. Replacing one-fourth of the hydrate by cement does not greatly improve the strength, but the use of equal parts of hydrate and cement gives excellent results.

It is thought that a mixture of ⅔ hydrate of lime, ⅓ cement and 3 or more parts of sand would make, with the addition of hair, an excellent hard wall plaster, which although it might harden a trifle slowly, would be extremely strong and durable. Such a plaster should prove better than hard plasters made from gypsum products, and can be incorporated in its dry state with both hair and sand, ready for immediate use. Great care should be used when mixing with cement, to use a hydrate entirely free from core or unslaked lime, a little of which would produce very disastrous results by swelling.

It has been demonstrated conclusively that it is possible and practical to produce a perfect hydrate of lime, which contains no core, will not pit or pop, which retains all of the properties of quick lime, and the rapid growth in the use of this material is surprising. The combined capacities of the hydrate plants at Rockland, Cedar Hollow, Toronto, Milltown, Marblehead and White Rock are nearly 300 tons per day. There years ago the total output of this material in the United States was about 23 tons per day.

The last comparison of importance between hydrate of lime and quick lime is that of cost. The actual expense of reducing ground quick lime to a hydrate is about 25 cts. per ton, taking it for granted that water can be obtained free, as would be the case at most quarries. The increase in finished product, on account of added water, would more than take care of the cost of hydration, so that it is possible to put this material on the market at a price actually lower than quick lime.

As to efficiency of each, it can be said that the hydrate, on account of its very finely ground form, will carry additional sand. It can be more thoroughly mixed with sand, water and other ingredients, so that notwithstanding the presence of a certain amount of water it is about equal in efficiency to common lime. The fact that it is so much easier and more certain than quick lime suggested by a recent Federal Court suit, involving more than $100,000, for default and damage and the rejection and reconstruction of a sewer system resulting primarily from the inability of the contracting firm to fulfill a clause of a contract limiting the leakage of the sewer mains to 5,000 gallons per day per mile of sewer. The designing and constructing engineer retained by the municipality was a man of mature years, long experience and high technical and intellectual attainments. In the specifications for a previous sewerage works, the leakage had been limited to 1,200 gallons per mile in 24 hours, and while no weir measurements had been made the noticeable leakage in the previous system had suggested the advisability of increasing the permissible quantity, which was done as stated. The head of the contracting firm, besides being an experienced sewer contractor, was a member of the American Society of Civil Engineers, and neither the engineer or contractor entered into the work with any misgivings as to the particular clause limiting the leakage system.

The city in question lay largely on the low, alluvial bottom lands along the Mississippi River, and was protected by a low levee. As designed, the invert of the outfall was 31 ft. above extreme low water, but in time of high flood the river reached a point 19 ft. above the outfall, and at such times the sewage was collected in a sump-well and discharged mechanically over the levee. Owing to a difficulty in securing Government consent to cutting the levee, the entire system was completed before the outfall was constructed. The trenching was for the most part through saturated soil.

Work progressed uninterruptedly and smoothly until completion, but when the final estimate was presented the city authorities declined to accept the interpretation of the engineer upon certain claims for extras, and gave him written instructions as to how the estimate should be made. Failing to secure the settlement desired, the city officials dispensed with the services of the engineer and retained another to represent them, instructing the latter also to inspect and report upon the physical condition of the system. To that time no question beyond a financial one was involved, but the report of the new representative disclosed the fact that instead of 5,000 gallons per mile the leakage amounted to 44,600 gallons per mile per 24 hours, and relying largely upon this substantial difference, the city rejected the sewerage system and called upon the surety company to rebuild same, which action has resulted in a long, tedious and expensive litigation, during which numerous engineers and expert witnesses have been retained by either side. Being one of the witnesses for the defendant, and appreciating the trouble caused by this clause of the contract, the writer feels justified in reciting this particular case and in calling attention to this item, although not in position to add material testimony toward improved engineering practice in this particular.

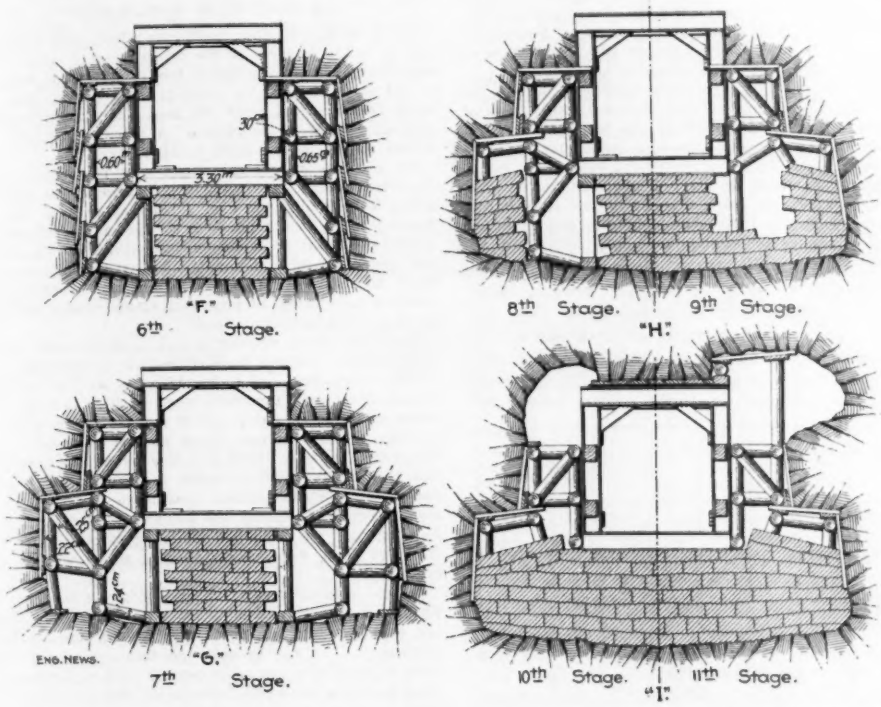


FIG. 16. SEQUENCE OF OPERATIONS FOR ENLARGING SECTIONS IN DISINTEGRATED ROCK, STAGES 6 TO 11.

INFILTRATION OF GROUND WATER INTO SEWERS.

By J. N. Hazlehurst,* M. Am. Soc. C. E.

To many of the older and more experienced members of the engineering profession the necessity for emphasizing the need of proper provision for the infiltration of ground water in the consideration of design and specifications for a sanitary sewer system may seem superfluous. That there is real cause for discussing this subject is

The older standard text and reference books give very little information on the subject of the leakage which should be provided for in sewer design, but both Folwell and Ogden touch on this question and give certain references and recommendations. According to Folwell, good work should not show more than 1 cu. ft. per sec. for 30 to 100 miles of sewers. This is a pretty broad margin, but an average of the extreme lengths gives 10,000 gallons per mile per 24 hours as a reasonable expectation for good work. Ogden has collected a number of references of the infiltration found under actual conditions, and quotes several laboratory tests, but confines his recommendations to the following:

> The evident lesson so far as ground water is concerned is that instead of adding a certain percentage to the desired capacity of the sewers, a more rational method is to consider in detail the length of pipe to be laid under a head of ground water, and to increase those lines and the mains lower down by a certain amount of leakage per mile, the amounts to be arrived at by actual experience and by the experiments quoted.

Amongst the tests mentioned was that made by Mr. Freeman C. Coffin, and published in the "Journal of the Association of Engineering Societies." His conclusion was that insurmountable difficulties in actual construction prevented a perfect cementing of pipe joints, but that in laboratory experiments it was possible to secure for standard pipe-sockets, with well-made joints of either neat Portland cement or 1 to 1 Portland or Rosendale, with over-filled joints, a leakage of not more than 1,000 gallons per mile per day with a level of the ground water from 2 to 8 ft. above the pipe.

Mr. Coffin's results have been closely approximated by the writer, using two lengths of 8-in. standard sewer pipe, one end of each being fitted with close wooden stoppers, plastered over with neat cement, and after drying, painting with liquid asphaltum. The pipes were rigidly secured by an open wooden framework and then jointed with 1 part fresh Louisville cement to 2 parts clean, sharp sand. Exposed to the air, but covered with damp cloths for six hours, the joint mortar had taken a good set when the frame containing the pipe was immersed under 7 ft. of water and allowed to remain 24 hours. Upon removal, the joint was found to be in perfect condition. Carefully breaking the joint, 145 cu. ins. of water was found to have accumulated, equivalent to 1,329 U. S. gallons in a mile of pipe having 2½-ft. lengths. One now and again reads some set of specifications requiring that "pipe lines shall be water tight," which is a pretty hard proposition for a contractor to "go up against" when even in laboratory tests such condition is impossible.

Only actual experience under normal conditions should govern in such matters. A comprehensive report made to the Massachusetts State Board of Health by its Chief Engineer, Mr. X. H. Goodnough, and touching upon the question as to what might be expected from infiltration, may not have been seen by many of those interested in this subject. It is given in full here:

*Chief Engineer, Board of Public Works, Mobile, Ala.

LEAKAGE INTO SEWERS.

Nearly all sewers which are laid below the level of the water in the ground receive a considerable quantity of ground water through defective joints or cracks in the sewers, and the water which enters the sewers in this way has been found to form a large proportion of their flow. Numerous observations of the leakage into the sewers of various systems in the state have been made in recent years, and the results show that it varies considerably in quantity in different seasons of the year, being greatest in the spring, when the ground water is highest.

Records of the flow in sewers recently constructed, aggregating about 137 miles in length and ranging in size from 8 to 36 ins., show that the average leakage into these sewers before any connections were made with them amounted to 40,000 gallons per mile of sewer. Some of these measurements were made in the spring, at the time when the leakage was greatest, but others were made in the drier portion of the year. When connections are made with these sewers, it is likely that the leakage will be greater on account of the larger number of joints.

Fig. 1. Diagram of Disks for Friction Clutch.

Records of flow of sewage at all times of the day and night in about 700 miles of sewers of various cities and towns of Massachusetts indicate that the leakage in a large system would probably amount frequently to nearly 70,000 gallons per day per mile of sewer, and at times when the leakage is extraordinary to as much as 80,000 gallons per mile. The extensions to the various sewerage systems which will be made in the future in Metropolitan areas may receive a somewhat less quantity of water by leakage, since a larger proportion of the sewers built in extending the systems in the future will probably be constructed of pipes of smaller diameter, and laid in higher lands where the amount of ground water encountered may be less; but the increase in the number of the connections will probably cause an increase in the leakage into the sewers already built, and, on the whole, it seems desirable that provision should be made for a leakage of as much as 80,000 gallons per day per mile of sewer in the districts under consideration. Estimates based on the recorded flow of sewage from the Boston main drainage and the North Metropolitan sewerage systems tend to confirm the investigations as to the amount of leakage into the sewe s, and there seems no reason to expect that the leakage per mile will differ materially, for many years in the future, from the amount which it has been found to be at the present time.

In order to learn the relation between the leakage into the sewers and the population connected with the sewers it has been necessary to estimate the probable future population per mile of sewers in the Metropolitan areas. The population per mile of sewer in different cities and towns in the Metropolitan district varies greatly; but in those communities where the land is now nearly all occupied and where portions of the area are densely populated it is found that the average population per mile of sewer is about 800. So far as can be judged at present, this ratio appears to be a reasonable one to use, and upon this assumption the leakage into the sewers would be 100 gallons per inhabitant.

The quantity of water which may find its way through manholes at times of storm or melting snow has been found to be very considerable in the case of many sewer systems, and, in order to reduce the quantity, tight manhole covers have been used in some places instead of the usual perforated covers. It seems probable that the leakage of considerable quantities of surface water into the separate systems of sewers can be largely prevented in future, and it does not seem necessary to make further provision for an increase in the flow of sewage from this cause alone.

Commenting upon and supplementing this section of his report, the Chief Engineer in a personal letter to the writer says:

The observations to which you refer, which cover 137 miles of sewer, were made at different times, not all in the same year, and it would be impossible to state the actual number of square miles represented, since some of the districts were sparsely settled and contained few sewers, while in other places the districts were very thoroughly sewered.

The annual rainfall in Massachusetts is about 45 ins. per year, and was about the average in the years when these examinations were made. The distribution of the precipitation, however, varies greatly. In the winter snow often accumulates upon the ground to a depth of several inches and melts and flows off with the rains of March or April, so that the actual flow in the streams during that part of the year is often several times as great as the rainfall for a given period, taking even periods as long as two months. At such times the ground is filled with water and the leakage in the sewers is highest.

In designing sewers it is the practice to make allowance for leakage into the sewers. This leakage varies greatly under different circumstances and conditions. In places where sewers are laid through porous soil below the level of the ground water great difficulty is experienced in preventing a large amount of leakage, and sewers laid in low lands along the edges of rivers below the level of the river water or below the level of the sea are also liable to a large amount of leakage.

In designing the sizes of sewers, therefore, account is taken of the actual conditions in each case under which the sewer is likely to be laid and such allowance is made for leakage as the conditions appear to require. It sometimes happens that a sewer system when first completed, before any house connections are made, will show very little leakage, even in a wet period, i.e., in the early spring, but after numerous house connections are made with the system the same system may show a large leakage, due to faulty construction of house drains. I mention this to show that, even with a very carefully constructed system, there may be a large amount of leakage on account of careless construction of house drains, the introduction of which is not often under the control of the engineer.

In designing the high level sewer system in Boston, the district was such a long one that the maximum flow from the various districts would enter the sewer at different times so that no material allowance had to be made for the time of maximum use of water and consequent maximum flow of domestic sewage. I may add that in general the leakage into sewer systems in this state in the winter and spring is frequently greater in quantity than the flow of sewage proper into the sewer system.

The City of Malden, Mass., with a population of 34,000, has 45.45 miles of sanitary sewers. Records kept by the City Engineer show that the leakage upon the completion of 38 miles of the system was 50,000 gallons per mile of sewer, 60% of the work being in saturated soil. The drainage of the area covered by these sewers was 1,461

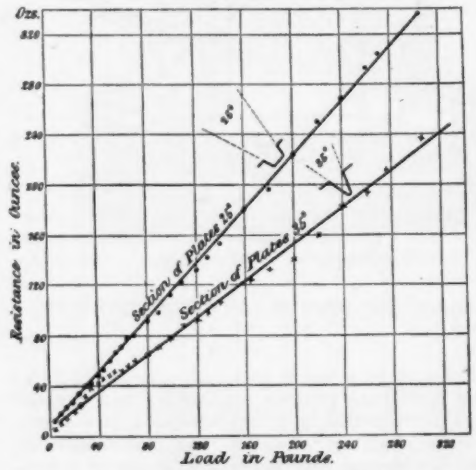


Fig. 2. Diagram Showing Relative Gripping Action of Disks With 25° and 33° Corrugations.

acres, of which 450 acres embraced a territory in which the sewers were laid from 1 to 6 ft. below the permanent ground water line. The rainfall for the year immediately preceding the gaging was 42.5 ins., or about 123,000 gallons per mile of sewer. The population per mile of sewer is 770, and the total leakage amounted to about 40% of the annual rainfall over the area sewered, or about 70 gallons per capita. Underdrains were used in construction, and jointing was done with neat Portland cement, 75 bbls. being used per mile of 8-in. pipe in wet work, and 63 bbls. in dry trenches.

In the design of the sewerage system of New Orleans, La., by Mr. Geo. G. Earl, many miles of sanitary sewers were provided for, covering an area of 22.9 sq. miles, for a population of 282,000 people. The total amount of sewage taken into consideration was assumed as being made up of 80 gallons of water per capita per diem, with a maximum flow of 160 gallons. The basis of allowance for ground water was 0.003 cu. ft. per sec. per acre, which gave a run-off equivalent to 1,250,000 gallons per sq. mile in 24 hours, or 31,800 gallons per mile of sewer. A portion of the New Orleans sewerage system having been constructed several years since by a franchise company, permission was obtained to pump out the completed sections in order to verify the assumed factor for ground water filtration. Tests were made which demonstrated the approximate correctness of the basis assumed.

In conclusion, no general rule or formula is applicable to all cases, each particular design requiring individual treatment, being a law unto itself, but it may be safely pointed out that with such materials as clay pipe and porous cement mortar joints, laid under the uncertain and arduous conditions incident to sewer work in general, "a water-tight pipe line" is a delusion and a snare for the contractor and the engineer of the municipality, and before setting a limit upon the permissible leakage it behooves the engineer to be very sure of his ground, both literally and figuratively.

A NEW FORM OF FRICTION CLUTCH,*

By Prof. H. S. Hele-Shaw.†

Stated briefly, the four conditions which seem to be involved in the problem of the friction clutch are: (1) It must have sufficient gripping power; (2) undue wearing of the surfaces must be avoided; (3) provision must be made for conveying away the heat where there is much slipping contact in the clutch; (4) motion should be imparted to the driven shaft without shock.

We are thus met at the outset with the contradictory conditions which have made the problem of the friction clutch such a difficult one. The author does not remember seeing in any previous writings on the subject, or in the statement of inventors themselves, the important fact mentioned in condition (3), but it certainly does account for the large number of instances in which friction clutches have failed to give satisfactory results for anything but the smallest powers.

There are plenty of illustrations in mechanical science where it has hitherto been impossible to reconcile conflicting conditions, such for instance as the variable change speed gear, especially when required to be of high power and high efficiency, and it is an important question whether the present case forms another example or not. The author believes there is a way out of the difficulty, and this he proposes to bring forward in the present paper. It is quite possible that there are other ways, and if engineers consider the matter of sufficient importance, it may put them on the track of overcoming the difficulty by a way other than that which will be now described.

Suppose a sheet of metal is pressed into a frustum, the section of the corrugation being the frustum of a cone, and that the disk is placed upon another one similarly corrugated. It will be observed that not only do portions of the frusta not make contact with each other, but there is also a space left between the flat portions of the disks.

By placing these disks together as in Fig. 1, and turning one alternately to the other, an amount of friction is produced which depends on the acuteness of the angle of the frusta. If a number of these plates are now placed in a box of the type of the "Weston" coupling, so that the plates alternately engage with two sleeves, one connected with the driver, and the other with the follower, it will be found: first, there is very considerable gripping power; second, there is a tendency to part rapidly with heat, owing to the separation of the disks of metal.

By the ordinary theory of friction, the former effect—in a box of given length, if the gripping power is compared by actual measurement with the "Weston" clutch—will be found to be much greater, and yet this cannot be accounted for by the ordinary laws of friction, since the increased effect of the wedge action (which varies with the cosecant of the angle of the cone) is directly in proportion to the diminution in the number of plates which it is possible to put in a box, which diminution varies according to the same law. There is, however, a still more striking difference between the gripping action of the flat and corrugated plates when a lubricant is introduced.

The results of experiments which have been made with corrugated plates of different angles are graphically recorded in Fig. 2. Some explanation is therefore needed of this effect, and the conclusion has been arrived at that it is due—in part at any rate—to the necessary deviation from the truly circular form of the corrugations in the plates. Efficient lubrication of the surfaces in contact is insured by drilling the faces of the plates as indicated in the sectional view, Fig. 3. It will be noticed from this illustration that the number of plates in a given space depends upon the angle of the corrugation thus: Four plates with 30° occupy the same space as six plates with

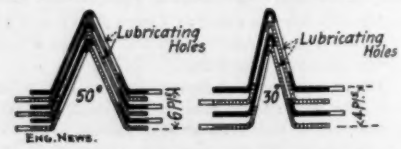


Fig. 3. Sketch Showing Circulation of Lubricant in Corrugated Disks.

*Abstracted from a paper read before the Institution of Mechanical Engineers of Great Britain, July, 1903.
†Liverpool, England.

50°. These four plates, however, give a better grip than the six plates with 50°, and have the great advantage of allowing a freer circulation of liquid, as may be easily seen from the figure. The plates are also much more rigid with the more acute angle.

Two views of a standard type of clutch for shafts up to 2 ins. diameter are shown in Fig. 4. The shaft is divided at A, the outside case B being keyed to the left-hand piece of shafting, and driving the set of plates having external driving teeth. The core C keyed to the right-hand shaft driving the plates with internal driving teeth. Pressure is applied to the plates as follows: The sliding sleeve D containing a coil spring is fitted with pins which project through the outside case of the clutch; these pins press against a flat disk, which in turn presses against the plates causing the clutch to drive. When the operating lever is worked so as to release the plates, the ring E encircling the sleeve withdraws the trigger pins from the holes into which they fit; the spring pressing on the opposite end of the trigger pin causes the trigger to fly up and the clutch is thereby kept out of operation. By moving the lever so as to force the ring E against the trigger, the pin-end falls into the hole opposite to it, and the coil spring is then allowed to transmit its pressure to the plates.

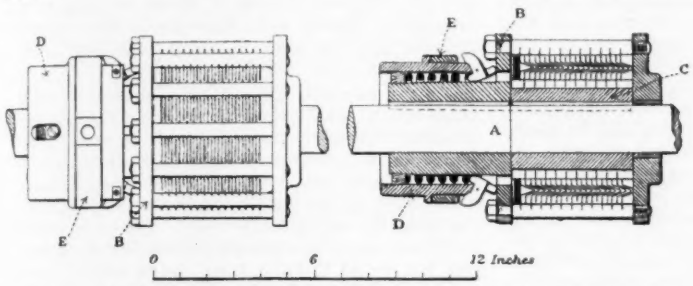


FIG. 4. STANDARD TYPE OF FRICTION CLUTCH WITH CORRUGATED DISKS.

A view of a clutch transmitting 80 HP. at 60 revolutions per minute is given in Fig. 5. One of the conditions of working of this clutch is that it should run for at least two hours daily transmitting only 30 HP., the main shafting running at its full speed of 60 revolutions. It must pick up its load gradually and without shock. The cooling and lubricating fluid is contained in the tank A placed on the ground. The fluid is raised to the clutch case by means of the small rotary pump B, driven by a band from the clutch case at C, the path of the fluid being indicated by arrows. It leaves the casing through a series of holes in the periphery, being discharged through these by centrifugal action. It is then collected in the annular trough D, which, fitting loosely over the revolving casing, directs the fluid back into the supply tank A. This clutch has been at work at Messrs. Pilkington's Plate-Glass Works, St. Helens, for a period of five months, working day and night, and fulfilling eve.y requirement satisfactorily.

The clutch is the chief factor in a wheel train reversing gear, and the author has recently designed such a reversing gear in which the new clutch is employed. This reversing gear, shown in Fig. 6, consists of two clutches A and B. The outer case of the clutch A is keyed to the reversing shaft C, which may be a propeller shaft, the core of A being keyed to the engine shaft D. Inside the rim of the outer case of A teeth are cut in the direction of the shaft, forming an annular wheel H. To the internal core of clutch B, a series of pinions are fixed as shown at J, these pinions gear with the annular wheel H. They also gear with the wheel K, keyed to the engine shaft, the three together forming an epicyclic train. The outer case of B is held stationary, being fixed to the frame of the machine by a bracket L.

The gear operates as follows: When the lever M is in position C^1, clutch A is made free and clutch B comes into action. The core of B carrying the pinions J is now fixed to the outside case of clutch B (which is permanently at rest), and, as the core of B is free on the engine shaft, the toothed wheel keyed to this shaft at K transmits motion to the pinions, which, being also in gear with the outside case of A, causes the shaft C, to which A is fixed, to rotate in a reverse direction and at a slower speed than that of the engine. When the operating lever M is in mid position both clutches are inoperative and the reversing shaft is at rest. When the lever M is in position A^1 clutch B is free, at the same time the plates in clutch A are caused to grip, and as the outside case of A is keyed to the reversing shaft and the core of A to the engine shaft the two rotate together in the same direction. The toothed gearing at H, J and K, now rotate as a fixed mass, the teeth themselves not being in operation. The presser rings of clutches A and B, on this gear are fitted with the spring and trigger arrangement described previously in connection with Fig. 4. The locking system of operating links and levers renders it impossible for both clutches to grip simultaneously, no matter how suddenly the operating lever M may be moved from one extreme position to the other. The enclosing case of the whole gear acts as an oil bath, and thereby ensures an efficient system of lubrication.

This reversing gear has been successfully applied in the new 20-HP. motor launch made by Messrs. Thornycroft for His Majesty.

The action of this type of reversing gear may be made as quick or slow as desired, but with the fairly heavy flywheel attached to the gear shown on Fig. ..., it has been found possible to change from full speed in one direction to full speed in the opposing direction in 5 seconds.

Applied as a dynamometer the corrugated surfaces are quite successful. A friction dynamometer of this type of 600 HP. has been constructed for Messrs. Vickers, Sons & Maxim, Barrow. It may be pointed out in connection with these dynamometers that the speed can be reduced to a very low number of revolutions under the conditions of pressure at the engine without impairing the accuracy of the observations, while the running remains perfectly steady for very great loads. Although this dynamometer has been at work for many months the plates have not worn to any appreciable extent.

The author has mentioned a number of applications of the clutch which have been already made, but the application which really led to its invention was in connection with the motor car. A satisfactory clutch is one of the most difficult things to secure for this purpose. The ordinary type of cone clutch, which is generally employed, the cone of which is covered with leather, can rarely be maintained in a normal condition for the following reasons: A great command over the car, especially in driving through traffic, is secured by allowing the clutch to slip. When slipping has been going on for some time the surfaces are

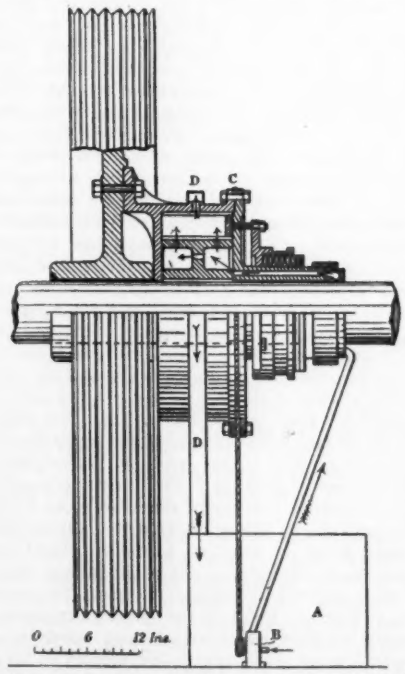


Fig. 5. Detail of Clutch Transmitting 80 HP. at 60 Revolutions per Minute.

generally so altered in their condition that either the clutch will not grip at all or it grips violently and harshly. The result in driving is not only most unpleasant but it is very inimical to the car itself.

The author originally fitted one of his new clutches to a fairly heavy car, on which the engines had been changed from 6 to 12 HP. This clutch, although the plates were only 6 ins. in diameter, drove the car so satisfactorily that the 6-HP. gear has, under very trying conditions of the British Association tests on road resistance, been found quite strong enough for the purpose. Since then he has changed the cone clutch of a 24-HP. Darracq car for one of the type described in this paper with remarkable improvement in its action. It has been found capable of driving the car so altered, although a fairly heavy one, for long distances, even in hilly country and without ever going off top speed, which is a direct gear to the driving wheels. The actual speed at the normal revolutions of the engine on this car is 70 kilos. (i.e., about 45 miles) per hour. This example shows the possibilities of the clutch, with which the car can be driven for any required distance at the speed of 3 or 4 miles per hour, or even less, and after running for an hour or two under these conditions the clutch does not get hot. Of course the main object of the change gear, which is to increase the power if necessary, is not attained, since the slipping of the clutch can only involve loss of power, but this is a case in which, with an engine of sufficient power, variation in the range of speed is really a more important object rather than the saving in power.

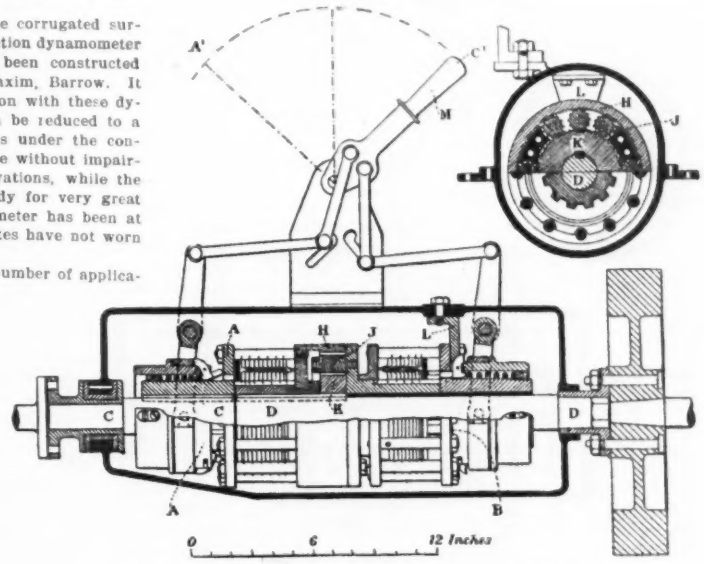


FIG. 6. DETAILS OF REVERSING FRICTION CLUTCH.

THE QUESTION OF SYNCHRONOUS vs. induction motors, which was more discussed some years ago than it is at present, was touched on in a paper on "Electric Power for Mining Purposes," read by Mr. G. Scarfe before the recent convention of the Pacific Coast Electric Transmission Association. The author advocated the use of synchronous motors for driving stamp mills for the reason that their speed remains constant and is not affected by voltage variations, such as occur on any distributing network. As the stamps have a definite time of falling, the lifting mechanism should run at a speed closely suited to this time of falling. The variations in speed of an induction motor due to voltage changes may be sufficient to affect the satisfactory working of stamp mills.

A SINGLE-PHASE RAILWAY MOTOR has been constructed by Mr. G. Finzi, of the firm of Brioschi, Finzi & Co., of Milan, Italy. The motor was recently tried on the street railway lines of Milan. The motor is electrically the same as a direct-current series motor, with completely laminated magnetic circuit. The punchings for both armature and field were more carefully insulated than is usual in direct-current motors, and, the pile-pieces have numerous slots parallel with the shaft to minimize the fluid distortion due to armature reaction. The motor is said to be as sparkless as the ordinary direct-current railway motor. For the practical trial this motor was fitted to one of the single-motor cars of the Milan street railway, in place of a direct-current motor of 27 rated HP. The speed control was accomplished by a variable-ratio transformer connected with a 5-point controller. No starting resistances were employed. The line voltage was 570, and this was reduced to from 80 to 160 volts on the motor. On several successive days the whole street-car network was closed down for the trials, during a period of several hours, and the trolley-wire supplied from a special alternator with alternating current of 570 volts at 18 cycles. The car weighed 9 tons. During the several runs an aggregate distance of some 150 miles was covered. It is said that the trial was completely successful. Speeds up to 30 miles per hour were reached, and the car started on a 2½% grade as easily as do the direct-current cars. The power consumption ran up to about 20 KW. at times. The motor with its auxiliary equipment is said to weigh about 10% more than the direct-current motor and equipment. A short account of the trials is given in a recent number of "The Electrician," of London.

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Are there any fire hydrants in American cities that are artistic in design, or that even possess the negative merit of not being offensive to an artistic eye? In asking this question we are but restating a portion of a letter of inquiry that has been received by this journal. The body of the letter is as follows:

> Can you help me to get a sketch or photograph of some really *handsome fire hydrants* for street use? I am told that some foreign cities have such—our cities do *not*.

Assuming that our correspondent uses the term "handsome" as synonymous with artistic, is his sweeping criticism of American fire hydrants just? For the present the questions raised will be left to the readers of this journal, with the request that so far as possible their answers be in the form of sketches or photographs of artistic fire hydrants in actual use, whether in this country or abroad.

The infiltration of ground water into sewers on the separate system has not received the attention that it deserves. This fact is emphasized in an article by Mr. Hazlehurst, elsewhere in this issue. The article illustrates anew both the desirability and the difficulty of securing better joints, to the end that infiltration may be reduced. The author does not refer in detail to the available methods for reducing infiltration. These are: (1) Better workmanship in making cement joints. (2) The use of greater lengths or sections of vitrified pipe, and (3) of deeper sockets. (4) Drains beneath the sewers. (5) In special cases, the substitution of cast-iron for vitrified pipe. Various combinations of the first four will suggest themselves to our readers. Unfortunately there is available comparatively little information regarding the relative costs of the various methods and combinations thereof; any more than there is available reliable data as to infiltration under varying conditions of actual service. The subject is of such rapidly growing importance that unpublished data would be welcomed for use in these columns.

There is material for profitable study by the managers of small machine shops in the progress which has been made during recent years in the development of machine-shop methods. This progress has been realized from a study in two directions: First, to decrease the labor-cost of the product, without regard to the plant involved, and second, to increase the producing capacity of a given plant, without regard to the labor-cost involved. The two purposes have proved to be convergent, in general. The results of the two lines of endeavor have value for both the small and the large producer. But since the machine-building industry, like any other, rests on the work of the small producer, those achievements which operate for the profit of the small shop are of prime importance. It requires time, of course, for new methods to gain introduction and acceptance everywhere; first the knowledge and appreciation of their value must spread through the ranks of shopmen, down to the smallest shops, and then a further time is required to overcome the inertia of existing machinery and equipment. But the total period of introduction may be much shortened, with advantage to the machine industry as a whole, if every shop-manager studies new methods and advanced ideas as they prove their worth, and considers how he may apply them to his work to increase his profits. Even now there are many new methods and appliances which promise economies for many shops and factories that have as yet not considered their use. Pneumatic tools can be made a source of profit almost everywhere; only in the small minority of shops does the cost of the additional plant required equal the saving in labor for chipping, drilling, reaming or hammering. High-speed tool steel can be used in every shop to reduce the cost of roughing cuts. Very few machine-tools are now worked up to their limit of strength, or operate in service so heavy that they would not stand the increased demand on their strength and power which is involved in the economical use of the new steel. The milling-machine and the emery grinder have already won fairly wide adoption. To a lesser extent this is true also of standard gages and limit-gages; the old notion that gage-working is necessary or economical only in "interchangeable" production has been quite thoroughly done away with. Trackway or trolley-hoist systems have been shown by experience to be time and money-savers in small and moderate-sized shops as well as in more extensive establishments. Driving machine-tools by electric motors, individually or in groups, has been so well developed that very many new shops are designed for it from the first, and its adoption in a large number of existing works, scrapping the existing transmission plant, may be taken as proof of its value in cutting down coal bills (and sometimes labor-cost, by giving readier speed-change and better control generally). For existing shops of small size, of course, the extra capital outlay will in most cases prohibit the adoption of electric motor driving. Then there are other methods, such as the use of machine tools which are brought up to the work, that are suited only for large work or work of a special class; but because these methods do not apply to the small shop their general importance is less. The same is true to a large extent of advanced methods and principles in shop management and administration which have given gratifying results in large establishments. But leaving these out of account, there are abundant opportunities, as we have tried to suggest, for the small shop to make use of the experience gained in larger works, and by a progressive attitude to improve its profit balance.

METHODS OF MACADAM CONSTRUCTION IN SOME NEW JERSEY TOWNS.

There is probably no section of the United States that has more hard roads than northeastern New Jersey, and this holds true not only of the country districts but of the towns as well. The streets that are now being macadamized are, for the most part, laid in short sections under private contracts, and it is interesting to note the form of construction that has been developed by this system of private contracts. Since the owners of property know little themselves about engineering practice in road building, the contractors have been left to their ways of construction, and not with such dire results as some might have predicted.

Streets average about 40 ft. in width between "curbs," if the sodded edge of the roadway can be called a curb; and the macadam occupies an average width of 16 ft. in the center of the street. A trench 16 ft. wide and 8 ins. deep is dug to receive the stone, and most of the earth is hauled away, although enough earth is left piled on the sides to be used as a binder. The crown is ordinarily a 5-in. rise in 8 ft. for the macadamized portion of the street and slightly greater for the earth sides. After grading no attempt is made to roll the subgrade, which, it should be stated, is sometimes sandy and sometimes very argillaceous, but generally a sandy clay that ruts badly when wet.

For the so-called Telford bottoming, trap rock is generally used, although occasionally shaley sandstone gathered from the fields is used. The trap rock is delivered in sizes such as would be fed to a small jaw crusher. Slat-bottom wagons holding two or more cubic yards are used in hauling from the quarry to the road. The stone when delivered is broken up with knapping hammers and laid so as to form a bottoming about 5 ins. thick. A laborer breaks and lays about 5 cu. yds. of this bottoming in 10 hours. Trap rock breaks irregularly, so of necessity there is no attempt made at building the orthodox form of Telford with stones set on edge. As a matter of fact this so-called Telford is really a macadam road in which very large stones are used for the bottom course; and this it is also because the lower course is bound with earth in a more or less thorough manner. After the 5-in. bottoming is laid, earth is shoveled from the heaps at the side on to the stones, covering them to a depth of perhaps 1 to 1½ ins., and a horse roller passes several times over the stone. Then more earth is spread over the stone foundation, upon which the wearing coat is next spread. This wearing coat is 3 ins. thick and consists of stones not over 1½ ins. in diameter. It is not rolled at all before binding, but earth from the sides of the street is cast upon the stone to the depth of about an inch, then the rolling begins. The roller ordinarily weighs about 5,500 lbs., and is made in three sections, each having a 12-in. face. The team used to pull the roller is unhitched from time to time and hitched to a sprinkling cart, so that rolling and sprinkling alternate until the macadam is bound, although on large jobs an extra team is used on the sprinkling cart. Toward the last of the rolling some trap rock screenings are spread over the macadam, more for appearance sake than for anything else. A team will sprinkle and roll about 100 ft. of this 3-in. macadam, 16 ft. wide, in a day, which is equivalent to about 15 cu. yds.; but the solidity of the resulting macadam is by no means equal to that of macadam rolled with a steam roller, although in time the rolling of wagon wheels makes as hard and smooth surface as one could wish.

It will be seen that the kind of macadam just described is not such as an engineer would ordinarily specify, yet there are several features about it well worthy of thought. In the first place there is a bottom of stones so large that Macadam would have condemned the structure on sight, yet it is seldom that one finds a spot where any of these large stones have worked to the surface. In such places the working up of the large stones has evidently been due to the use of insufficient earth binder. Indeed, one of the most serious defects of this bottoming is the slipshod rolling and binding. If it were more thoroughly rolled and if more earth were used to bind it, there is no doubt that an excellent and cheap foundation would thus be secured. We

say this with confidence in view of the general excellence of the pavements as they now are.

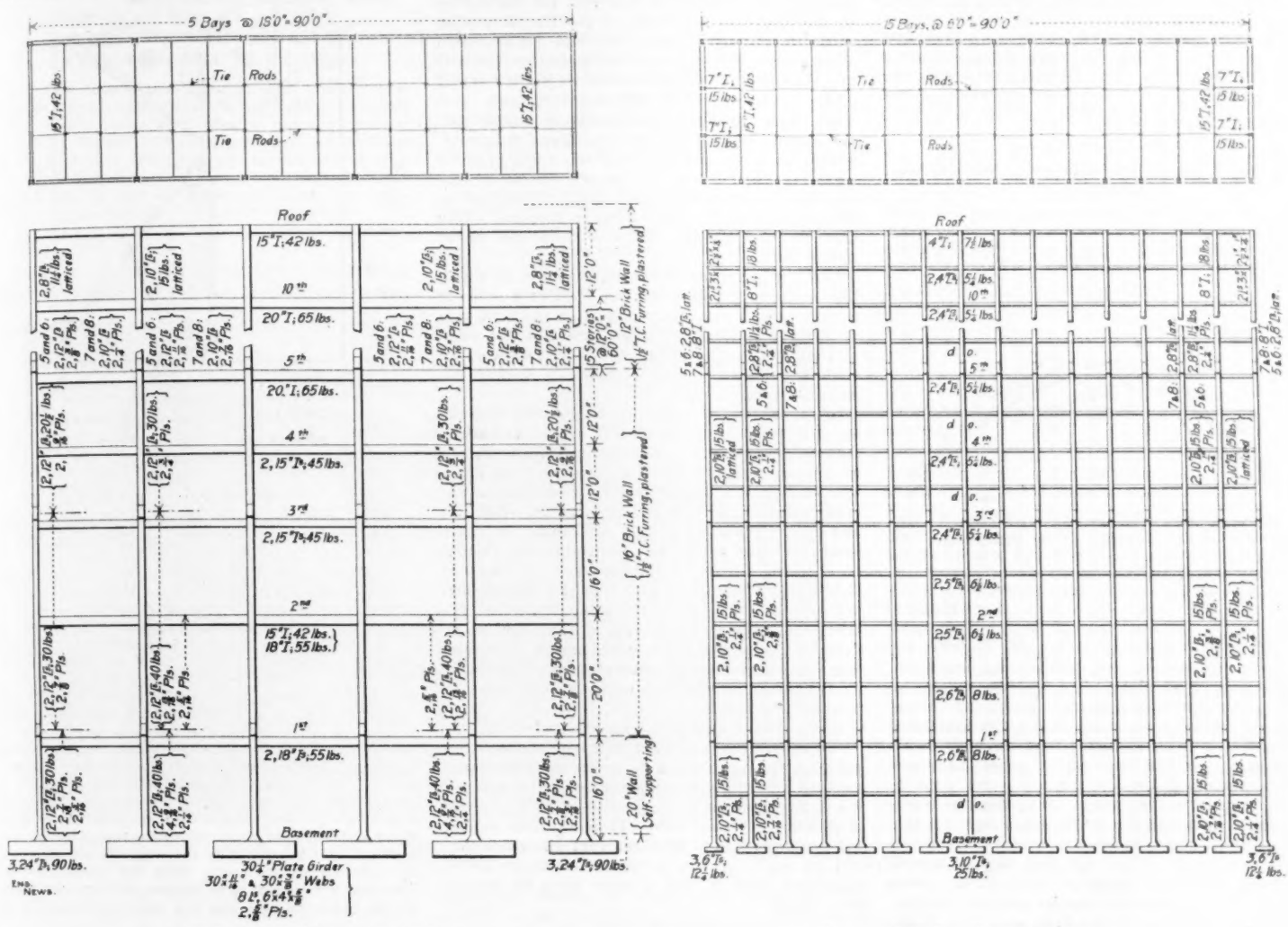
As to the binding of the 3-in. wearing coat entirely with earth we cannot speak so favorably; for while a fairly good surface is produced by the present methods, it by no means equals in durability the macadam that is bound with stone screenings. Trap screenings, it is true, bind very slowly and with difficulty even under a steam roller, while under a horse roller they can scarcely be made to bind at all. However, the proper procedure is not to use earth as a binder, with a dab of screenings on top, but to use screenings as a binder with a dab of earth on top; for a little loam or sand will do no harm and will effect the binding quickly. Better still is the use of a small amount of limestone dust on very fine screenings, instead of the loam on top of the trap screenings. A wagon load of limestone dust used in this manner will go a long way, and where available at moderate cost is to be recommended.

Regarding the horse roller, it is well known that engineers have for a long time condemned it as being more costly in use and less efficient than a steam roller. Nevertheless the horse roller seems to have a field of usefulness even yet.

Let us assume that it does produce a road having somewhat less solidity when first finished. How long does it remain less solid? But a short time in most cases, for the wagon wheels quickly finish the rolling. There is no doubt that a steam roller is always to be preferred on extensive road work, such as many of our States are engaged in, because it rolls the macadam at less cost, rapidly and with certainty of making a compact roadway; but in hundreds of small villages that now have no macadam at all the horse roller has a field of usefulness. Where only a mile or less of road is to be built each year it would be poor business policy to buy a tool costing several thousand dollars. In such places a horse roller will prove the most economic investment at first, and after a considerable area has been paved a steam roller will follow as a matter of course, for no other tool compares with the steam roller in breaking up an old macadam crust preparatory to re-leveling and re-rolling.

While the horse roller has been used to build satisfactory macadam streets in New Jersey, there are places where it has proved a failure. So far as can be learned such failures have occurred where small stones were laid upon a clay soil, and imperfectly bound. Later, when the rains saturated the ground, the clay worked up and the stones worked down, breaking up the surface of the pavement. On the very same soil steam rollers have made compact macadam roads that do not go to pieces; and had the so-called Telford construction of New Jersey towns been used it is not improbable that the horse rollers would have produced a solid and lasting roadway.

In drawing specifications there is always a tendency to specify "the best;" in other words that which has the finest appearance or is the most durable. This tendency often leads to real extravagance, in spite of the belief that "the best is cheap at any price." "The best" is often so high priced that very little if any of it can be afforded at all. So it has been with pavements. It would be no more absurd to see a man walking without shoes because he could not afford "patent leathers" than it now is to see villages and cities going without pavements because they cannot afford "the best."



COMPARISON OF COLUMN AND GIRDER AND "BALLOON FRAME" CONSTRUCTION FOR A LOFT BUILDING.

LETTERS TO THE EDITOR.

"Balloon Construction" for Steel Skeleton Structures.

Sir: A comparison of the methods in general use for framing the walls of wooden buildings and of steel skeleton buildings will show that the former—the so-called "balloon construction"—contains an economical suggestion which may well be adopted in the latter. When a wall is without openings, or has openings whose widths do not exceed the span of the floor arches, why should the columns on which it is carried be spaced as far apart as those in the interior of the building? Such a practice requires the use of girders of considerable span to collect the weight of wall and floors into the columns, and a correspondingly large projection of foundations to spread it out again on the ground. If, however, the columns in such a wall—the party wall of a building on a city lot, for example—are spaced so as to bring a column at the end of each floor beam, the weight of the floors travels directly to the foundation without any intervention of girders, and the girders required to carry the wall are very much reduced in span; the spread of the foundation is correspondingly decreased, and a considerable portion of the weight of the steel work is saved.

To illustrate my contention, I submit herewith two designs of a loft building, supposed to be built on a city lot 25 × 100 ft., with one street front and three party lines. A space of about eight feet is left at the rear of the lot for light and air. The floors are all figured for a total load of 200 lbs.—120 lbs. live and 80 lbs. dead—and the roof for 50 lbs. live and 70 lbs. dead load. The side or party walls are 12 ins. thick from the fifth floor line to the top, and 16 ins. thick from the first to the fifth floor lines, all carried on the skeleton frame. The basement wall, 20 ins. thick, is self-supporting. The front and rear walls are figured as if solid, and of the same thickness as the side walls, it being assumed that the openings for doors and windows will be counterbalanced by added thickness for architectural effect. The walls (except the parapet) are all furred with 1½-in. terra cotta blocks, and plastered.

The beams are proportioned with an allowable tensile stress of 16,000 lbs. per sq. in., and the columns according to the New York building law

$$\left(15{,}200 - 58\,\frac{l}{r}\right).$$

The columns are figured for the full live load of all floors. The foundation is supposed to be on concrete, at an allowable pressure of 15 tons per sq. ft. It is also assumed that the space required between the grillage and the party wall prevents the grillage girders being more than 2 ft. wide.

The weight of the steelwork in the party wall alone—columns, girders and grillage—in the design made by the method suggested above is nearly 25% less than required by the other method. The cost of fabrication will probably be about the same in both designs, for while our new method requires a slightly greater weight of columns, the columns in the upper stories are simpler of construction than those in the other design. The cost of erection should be less in the new method, as many of the pieces are light enough to be lifted in place without the use of the derrick.

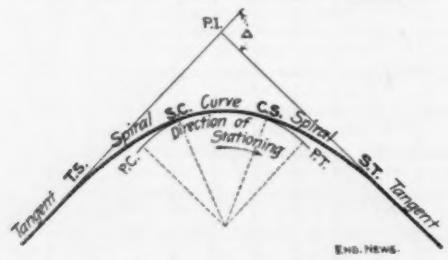
The employment of wall girders twice in the height of a story, as adopted in the illustrative design, is not essential to the method. Even without it we probably secure a stiffer construction than by the method now in use.

Very truly yours, Louis L. Calvert.

New York City, Aug. 1, 1903.

Suggested Standard Forms of Lettering Points on Transition Curves.

Sir: In running track centers, there appears to be no general uniformity in the practice of designating points at changes of alinement when spirals or transition curves are used. The accompanying sketch, illustrating a simple and clear method of lettering these points is submitted with a view of helping on the establishment of a desirable system. The letters P. S. and P. C. C. having other well defined meanings should not be used in connection with spirals.



Yours truly,

E. L. Hurley,

Asst. Engr., N. Y. C. & H. R. R. R.

417 Western Ave., Albany, N. Y., Aug. 10, 1903.

(Our correspondent very pertinently urges the desirability of adopting some uniform system of designating the critical points of railroad curves where transition spirals are used. The beginning of the first spiral is indicated by T. S. which is an abbreviation of the hyphenated term Tangent-Spiral; whereas the end of the last spiral is the S. T., the Spiral-Tangent point. The point where the first spiral ends and the simple curve begins is the Spiral-Curve point, or S. C.; whereas the point where the simple curve ends and the last spiral begins is the Curve-Spiral point, or C. S. This nomenclature is certainly simple and not confusing, and it leaves to the old P. C. and P. T. their well known significance. The use of P. C. C. (point of compound curve) may be defended as being equally as clear as the use of S. C.; it possesses the disadvantage, however, of being confusing in that it may also indicate the C. S. To use the longer expression, P. C. C., is tolerable where there is only one such point in a broken curve composed of two simple curves, and where such broken curves occur seldom; but the length of the term is objectionable, and to add a sub-numeral makes a bad matter worse. P. T. C. is also used by some engineers instead of the T. S. recommended by our correspondent, and P. T. C., instead of his C. S., while P. T. is used instead of his S. T. There is no question that these sub-numerals are objectionable in the eyes of many engineers, however little they may be so in the eyes of others; and so long as sub-numerals continue to be used at all there is very little likelihood of ever securing general uniformity. Expressions of opinion from our readers will undoubtedly hasten the adoption of some uniform system of notation of critical points on transition curves.—Ed.)

A Proposed Concrete Pavement.

Sir: I beg to inclose herewith blue print of a proposed concrete macadam pavement, of which an experimental section will probably be laid in this town, and would ask you, through the columns of your paper, if this form of pavement has been used in the United States, and if it has proved satisfactory?

This pavement is proposed on account of having gravel and sand of a good quality close at hand, and no broken stone suitable for macadam pavements.

Yours respectfully, "Subscriber."

Athens, Pa., Aug. 17, 1903.

(The cross-section of the proposed gravel concrete pavement accompanying the letter of our correspondent shows a 4-in. base of gravel concrete, specified to contain one barrel of Portland cement per cubic yard of concrete; and upon this base is a 2-in. wearing coat composed of 1 Portland cement, 1½ to 2 sand, and 4 gravel. Replying first to the query as to the previous use of concrete pavements, we can find no description of any concrete pavement in the United States, aside from some concrete alleys in Philadelphia. In Grenoble, France, concrete pavements are said to have proved satisfactory, but we know nothing of the travel to which they are subjected. One often sees cement sidewalks across which carriages pass into private driveways, and it is noteworthy that the edges of such sidewalks crumble away rapidly under the impact of hoofs and wheels. A smooth floated concrete surface is slippery, while a rough surface presents edges that will be quickly battered to pieces under heavy loads.

The great merit of macadam, it should be noted, lies in the fact that when the bond of a stone is once broken it will knit again after the next rain or sprinkling, provided the stone has not been entirely displaced. With concrete, however, no such knitting ever take place—once broken, always broken.

In suggesting a solution of the problem of making a hard clean pavement with gravel, two plans may be offered: The foundation, or 4-in. base, can be laid as designed by our correspondent, using evn less than a barrel of Portland cement per cubic yard. Upon this base two inches of gravel and sand (40% sand) may be laid and thoroughly sprinkled with crude oil, containing an asphalt base, as is the practice in making oil roads in California. This will produce a hard, clean wearing coat that will protect the foundation, and a coat over which heavy loads may be easily drawn. There will be none of the dust or mud that an ordinary gravel surfacing so often yields. At the worst, should this wearing coat not give perfect satisfaction, it can be removed and brick or other material substituted.

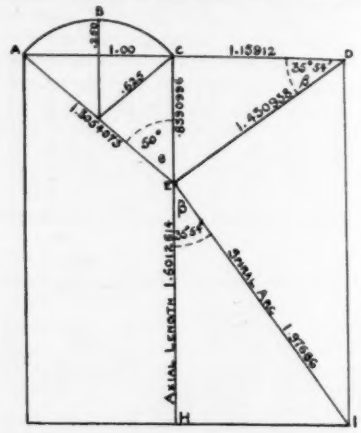
The second and more expensive plan for securing a wearing coat would be to mix the gravel and sand with some bituminous or asphaltic cement. We shall welcome a discussion of this problem of making a clean, hard pavement from gravel and sand, and it is to be hoped that an actual trial will be made of the pavement surfaces above suggested, even if only a short strip be laid at first.—Ed.)

The Construction of Skew Arches.

Sir: I have been interested by the article in your issue of June 11 on "The Stresses on Skew Arches," and in the subsequent letters thereon. On page 329 you reproduce an illustration of a skew arch from Rankine, which, along with the text books, I found to be altogether misleading, and so worked out the problem on mathematical lines, for myself, and published a book on skew arches which you were good enough to criticise in Engineering News. Rankine's plan of abutments, wing walls and counterforts is quite accurately shown, but no one ever saw the spiral-coursing joints of a skew arch anything like those given in Rankine's diagram. I should not be surprised at an arch coming to grief, if any one attempted to copy that example; and in Fig. 2, on the same page, if the thrust were in the direction of the arrows, it is no wonder that the acute angle was broken off. The only wonder is that the other acute angle did not share the same fate in this bridge near Bendigo, a place I knew well in 1864, when they were digging ("paddocking") for gold in the streets.

Now, I have found in my experience that, when properly understood, the building of a skew arch is a very simple matter. In the first place the pressure of all squarely-built arches is parallel to the face, or at right angles to the horizontal coursing joints. Then, the only secret in building a skew arch, if it is a secret, is to produce the same parallel pressure to the face, as is naturally in the square arch, by setting off the parallel spiral courses from the horizontal springer line on the impost or abutment at such an angle as will bring these parallel spiral courses out at the crown of the arch at right angles to the face thereof. In a skew arch so constructed you have the thrust parallel to the face, and every condition of the thrust the same as if the arch had been built on the square.

I have built several arches, at spans varying from 10 to 60 ft., and at angles from 70° to 40°, and have not had the slightest mishap, not even a corner nipped off a single stone through settlement after removing the centers, which is usually done at the end of a week after the arch is closed. I build all my bridges, both square and oblique, of the following proportions: The rise of the arc ¼ a fourth, and the thickness of the abutments, on the square, a fifth of the span; the radius in segments of these proportions is equal to half the sum of the rise and span, or span × .625; the length of the arc to chord 1 is



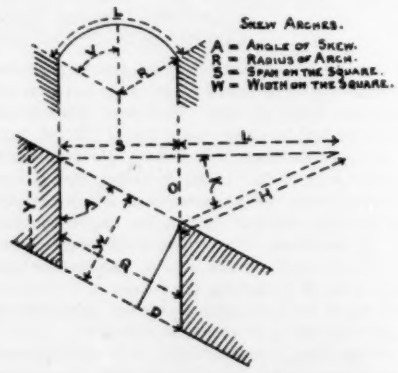
CDE AND HEI ARE EQUAL ANGLES

EI IS THE SPIRAL ARC, AND EH THE LENGTH OF ABUTMENTS REQUIRED FOR THIS ARC TO BE COMPLETE FROM SIDE TO SIDE.

Fig. 1.

1.15912, and the lengths of arcs of the above proportions are the chord or span × 1.15912, and the radius, span × .625, Fig. 1.

The theoretic intradosal skew-back angle is found thus: Given ◊ (the angle of obliquity) and the span; then the oblique span (A E) is = span × cosecant ◊, or span ÷ sine of ◊. The obliquity of the arch (C E) is = span × cot. ◊. The length of arc (C D) is = span (A C) × 1.15912 (by tables to chord 1). The length of the heading spiral or oblique arc (D E) is = C D ÷ cos. C D E or C D × secant C D E. Tan. C D E is = C E ÷ C D, which is the tangent of B or the theoretic intradosal angle, and is the key to the whole supposed difficulty in constructing a skew arch. To make this clear, take a sheet of ruled paper and place it at an angle round a plan roll, or other cylinder, at any angle you desire, and you will have a clear insight into the supposed mysteries of the skew arch. This is more reliable than the india-rubber test. Every arch stone and the checks on the impost are worked from the same twisting rules and templates and therefore fit accurately on the center along the spiral coursing joint lines, on any part of the lagging, and close the space on the center between side and side without having a



Q = Span on the Skew = S cosecant A

Y = Length of Impost = W cosecant A

O = Obliquity of Arch = S cotan. A

L = Length of Arc = .0349 RV.

= In Semicircular Arches = 1.5708 S.

$$\text{Sine } V = \frac{S}{2R}$$

H = Length of Heading Spiral = L secant K.

$$\text{Tan } K = \frac{S \text{ cotan. } A}{L}$$

D = Divergence of Courses = Y sine K.

Fig. 2.

stone to pave or a joint to pack; at least this is my experience. I have had to train all our masons myself and now have quite a number who are experts in the erection of skew bridges. It does not cost quite a penny more (2 cts.) per foot extra for dressing arch stones for a skew than for a square arch, but when men get accustomed to the use of the templates they can dress as many

feet per day of skew as square arch stones. Molesworth, on page 110, in his "Engineers' Pocketbook," puts the problem in a nutshell, as shown by Fig. 2. As I have elsewhere dealt with every detail of the skew bridge problem, from cutting the foundations to finishing the bridge, with illustrations showing the different stages during erection, I must apologize for this trespass on your space. I am, yours very faithfully,

Geo. Jos. Bell, M. Inst. C. E.; M. Am. Soc. C. E.,
County Surveyor and Bridge Master.

Cumberland, Carlisle, Eng., Aug. 12, 1903.

Joining Concrete Work Left Over Night.

Sir: I am desirous of getting accurate information as to what is considered the best practice in putting in concrete work where but one shift is used, for leaving off work at the end of the shift and starting again at the beginning of the shift. The point is to get the best present practice for leaving the fresh concrete in the evening so that a perfect joint is sure to be obtained when work commences in the morning. Respectfully yours,

D. C. Jackson.

Madison, Wis., Aug. 6, 1903.

[In the very complete specifications of the State Engineer and Surveyor for New York State road-work, we find the following clause, which may be said to embody the best practice in joining new to old surfaces of concrete:

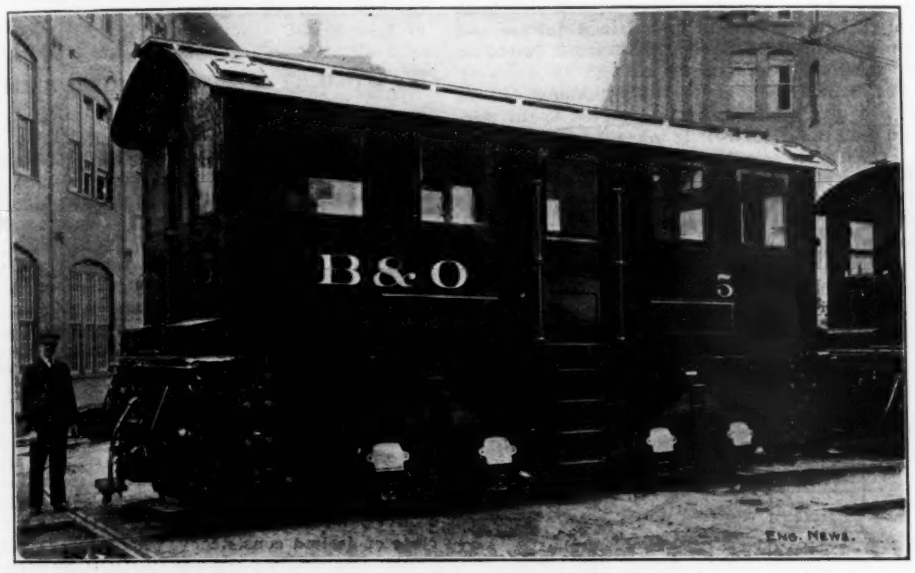
In joining new concrete to old work or to concrete that has already set precaution shall be taken to insure a perfect bonding by cleaning and washing the work already in place, and by spreading over its surface a thin layer of mortar before the new concrete is placed. In order to bond successive (9-in.) layers, timbers 6 ins. square shall be bedded in the top of the layer when it is formed, and these shall be removed before the next course is deposited, leaving grooves in which to form a bond. . . . . All finished and unfinished work until thoroughly set shall be kept moist by sprinkling at short intervals for at least a week after completion. In warm weather concrete must be covered with canvas, or otherwise protected from the sun, and in cold weather it must be covered in such way as to retard freezing.

Some specifications require that the surface of the older concrete shall be harrowed before laying the next layer in the morning; and, after the harrowing, it is specified that a thin layer of neat cement shall be spread over the surface. In building walls and abutments it is always desirable to build in sections of such length that an even number of sections can be finished to the full height each day, for it is almost impossible to prevent the formation of a noticeable horizontal seam marking the junction of one shift's work with the next. Of course, rubbing and coating the face with grout will obliterate such seams, but, unless very well done, the wall is given a mottled appearance by the rubbing; moreover, where rubbing is done the forms must be removed while the concrete is still green, which often results in pulling out large fragments of the face of the wall. Where concrete is deposited in 6-in. layers, and where it is desired to secure a bond in both directions, a number of 6-in. wooden cubical blocks may be bedded in the last layer laid, so that when removed a number of mortises are provided for the fresh concrete to tenon with. To bond a vertical face of one section to that of the next, one or more uprights of 6 × 6-in. or 8 × 8-in. timber may be bedded in the concrete and removed before building the adjoining section; or a trough made of two 2 × 10-in. plank may be bedded with its open face against the plank forming the end of the section form.

On high core walls for earth dams cement bags filled with sand are sometimes used instead of plank to make the end faces of each section of concrete. Such bags are piled up so as to make steps, each step being about 3 ft. high.—Ed.]

SECTIONAL ELECTRIC LOCOMOTIVES FOR THE BALTIMORE TUNNEL OF THE BALTIMORE & OHIO RY.

For the past eight years the traffic through the Belt Line tunnel of the Baltimore & Ohio Ry., by which that railway enters the city of Baltimore, Md., has been operated by means of electric locomotives. The tunnel is about 1½ miles long, on an 0.8% grade, and serves for both freight and passenger traffic. In recent years it became desirable to use the electric locomotives for heavier service than hitherto, and new locomotives were therefore ordered. It was specified that they should be able to handle a train weighing 1,500 tons (including the steam locomotive) behind the electric locomotive, with a minimum speed of ten miles per hour on a 1½% grade (on the tunnel approach), and correspondingly higher speed on lighter grades. These conditions have been met by what is virtually a sectional locomotive, each section complete in itself and capable of operating alone or coupled in tandem with one or more others; multiple-unit control of the motors makes these sections, when coupled together, a single locomotive in effect.



80-TON ELECTRIC LOCOMOTIVE SECTION FOR BALTIMORE TUNNEL OF BALTIMORE & OHIO RY.

A view of one such section is shown in the photograph reproduced herewith. The four axles are fitted with four motors mounted one on each axle; a heavy cast-steel frame is spring-supported on the journal-boxes of the axles, and provides attachment for the draft-rigging. A light cab built over the frame serves to house the controlling mechanism. The weight of such a section is about 80 tons, all of which is on driving wheels; for the maximum service specified it is intended that two sections shall be coupled up and operated together, making a locomotive having 160 tons available for traction. These locomotives are to operate over a distance of 3½ miles, including the tunnel, the heaviest grade occurring on the portion of the line outside the tunnel. The motors are of sufficient capacity to haul the maximum train at full specified speed up the grade, return light, and repeat this service hourly.

The General Electric Co., of Schenectady, N. Y., who designed and built these locomotives (as well as those* hitherto used in the tunnel), have kindly supplied us with a statement of the principal details of the locomotive. The main body of the locomotive consists of a rectangular frame of cast steel, built up of four pieces; two side frames and two end frames, bolted together. The draft gear is attached to the end frames. The axle journal-boxes slide in vertical jaws in the side frames; these jaws are machined and fitted with wearing-shoes for sliding surfaces. The side frames rest by means of equalizers on semi-elliptic leaf springs bearing on the journal-boxes; removable wearing-plates are interposed between the springs and the boxes. The four axles are fixed rigidly in the frame, as regards lateral turning, but to enable the locomotive to take curves more easily the axles are given considerable longitudinal play in the journal-boxes.

The wheels have spoked centers and are fitted with steel tires 2⅞ ins. thick, the tread and flange being in accordance with the M. C. B. standard. The forged steel axles are 7½ ins. in diameter in the bearings for the motors, and 8 ins. in the wheel-fit, while the journal bearings are 6 × 12 ins. The journal-boxes are correspondingly heavy, but otherwise are quite similar to standard journal-boxes. They are arranged so that a journal-box can be removed without disturbing any of the other parts. Wheels, axles and motors may be removed by dropping into a pit or by raising the frame.

The cab is a sheet-steel housing, having a door in the middle of each side and end. The end doors allow of communication between sections when coupled together. Windows are provided on all sides, as may be seen in the view. The floor of the cab rests directly on the frame. It consists of an under floor of 1¾-in. matched hard pine and a ⅞-in. wearing surface of the same material, laid crosswise to the under floor.

As already noted, each section has four motors, one on each axle, mounted direct. They are of 225 HP. each (type GE-65). They are handled by a multiple-unit control system of the Sprague type. The master-controller is located in the right-hand front corner of the cab, and a duplicate one is in the diagonally opposite corner, so that the engineer stands in the front end whether running in one direction or the other. The engineer's valve of the brake system is located adjacent to the controller, in duplicate; one in each end of the cab. The remaining equipment of the locomotive comprises the brake apparatus (consisting of electrically-driven compressor, air reservoirs, brake-cylinders, valves and brake-rigging), an air-whistle, a bell, two head-lights, and pneumatic track sanders.

It should be remarked that our illustration does not show the collector shoes or their supports, but the lugs for their attachment are plainly visible below the oil-housings of the axle-boxes. Current at 550 volts normal pressure is supplied by a third rail laid alongside the track (when the first electric locomotives were put into use on this tunnel line the supply was from overhead Z-bar conductors; later a third rail was installed). As each locomotive section can develop 900 HP., it will require at 600 volts a current of 1,100 amperes; two sections pulling a maximum train will draw the enormous current of 2,200 amperes from the third rail.

Mr. W. D. Young is Electrical Engineer of the Baltimore & Ohio Ry.

THE STANDARD AND ITS USE IN SURVEYING.

By Edward Riordan, C. E.†

The origin of the "standard" dates back only a few years, when it was first used by the Park Department of what is now the Borough of the Bronx, New York city. Its utility having been established, it was adopted by the Topographical Bureau, and no field party is now considered fully equipped unless supplied with two of them.

The "standard" consists of a bar, and a movable arm or bracket, Fig. 1. The bar usually consists of a ¾-in. pipe, 6 ft. in length, having welded into each end a solid piece of hard tempered steel,

*See for a description of the old locomotives and the power plant for their operation Eng. News, Nov. 29, 1894.

†42 West 117th St., New York City.

one of which is sharpened to a point and the other broadened into a chisel edge.

The arm or bracket is made to slide along the bar, so that it may be clamped firmly at any point. An ideal construction is shown in Fig. 2, in which A is a bulbed tee having a bushing screwed into one end with a hole threaded to receive the handle B. The side is cut out so that it

Fig. 1. The "Standard" Used to Support a Plumb-bob.

may be removed from the bar sideways; this avoids sliding the arm the length of the bar, and also renders it possible to put the arm on the standard when it is firmly driven into the ground, for without the side of the casting being cut out, the upper end of the bar having the broad chisel edge will not permit the arm to slide over it. Here it should be noted that the standard should never be jammed into the ground without removing the arm, because the constant jarring breaks the handle B off short, thereby rendering the standard useless for most of its purposes. The bulb tee is used on account of its greater strength, and resistance to spreading when the handle is screwed into it and against the bar.

The horizontal piece B should be made solid and the threads at C should be made very coarse and have a good hold in the end of the large tee, where all the wear comes. The slot in the side of the large tee should be cut very little larger than the outside diameter of the bar, and the outer rim of it should be left so as to form a sort of hook to prevent the arm from slipping off the standard sideways when clamped. The dimensions given in Fig. 2 will be found about the best proportion.

It is not necessary to screw up the arm with all one's strength, as that strains the threads. Just enough to hold firmly is sufficient.

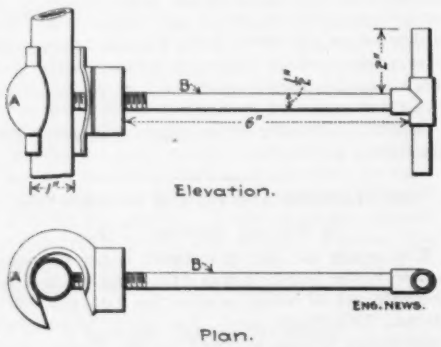


Fig. 2. Arm of the "Standard."

To prevent rust, which is disagreeable for the hands and injurious to the clothes, and to make it more discernible at a distance, the whole standard, bar and arms should be galvanized.

Sounding for monuments: Remove the arm and drive the standard into the ground. When a stone is reached the ring of the bar will generally determine whether it is the monument desired or only a stone.

Under ordinary conditions a depth of 4 ft. can be reached with this bar. If it is necessary to excavate a hole to uncover the monument, the chisel end of the bar may be used to loosen up the earth for shoveling.

To drive a stake into the ground, make a hole with the standard, where the stake is to be driven, and you will set the stake in less time, and in better condition than when no hole is made.

Without the arm the standard can be used for the various purposes of a crowbar, such as removing and resetting flagged sidewalks, removing stones, taking a board off of a fence, breaking down shrubbery, particularly blackberry brambles, or for holding back or bracing a limb of a tree, or a bush which you may not desire to destroy.

To take line from the instrument in setting a point, drive the standard into the ground beside the stake or place where the point is to come; put on the arm at the desired height and clamp it projecting over the place where the point is to come. Use the arm as a hand-rest in holding the plumb-bob, and when properly shielded from the wind, the point will be obtained quicker and more accurately than when the hand is rested on the knee, or held out in the air.

For hanging sights, probably nothing can be devised that would be better adapted to the purpose than the standard. It takes the place entirely of a transit-pole for back-sights or foresights, and gives a more accurate sight for line. To hang a sight, drive the standard vertically into the ground at the side of the stake, but not close enough to disturb it, having first removed the arm. When the bar is firmly driven, place the arm on and set it at the most convenient height.

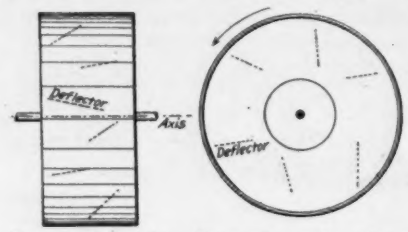


Fig. 1. Revolving Drum Concrete Mixer.

If there are obstacles, such as fences or hedges, it is well to have the transitman give the desired height of arm from the position of the instrument. Having clamped the arm securely, hang the plumb-bob approximately over the point, now place the background on the arm, chalk the plumb-bob-cord directly in front of it, and while shielding from the wind, carefully adjust the plumb-bob over the point; block up the bob so that it will not swing, and the operation is completed.

The illustration, Fig. 1, shows the standard driven in diagonally, which is sometimes necessary according to the location of the point, and a stick hung for sighting long distances, as the ordinary plumb-bob-cord is not thick enough to be used advantageously at a long distance. The background should be used almost invariably and hung so that the wind will not blow it against the cord and disturb it. If the wind is too strong, it should be fixed, if possible, separate from the standard.

When the standard is firmly driven into the ground and the arm adjusted to the proper height, an excellent support for the hand of the rear chainman is had, enabling him to hold steadily and thereby assisting the front chainman to set the new point quickly and accurately. A standard can be driven upright just behind the stake to which the chaining is directed to give the line.

A word about shield cloths. They should always be used for hanging sights, chaining and setting up the transit, even though there be very little wind. A little experience will prove the value of shielding.

In conclusion, it may be interesting to note what amount of accuracy is secured from the use of the standard and shield cloths.

With sights carefully hung at all the angle points and the shield cloths used in hanging them as well as in setting up the instrument, it is possible to read all the angles of a traverse with an average error not exceeding three seconds per angle with an instrument reading to twenty seconds, all the angles being turned six times continuously, and the final reading divided by six.

The error in chaining when standard and shield cloths are used can be kept within an average of 1 in 100,000.

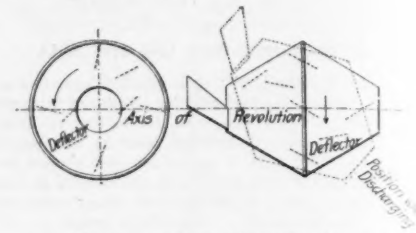


Fig. 2. Conical Concrete Mixer.

Compare this with the primary triangulation executed by the United States Geological Survey which closes with an average angular error of three seconds per angle and an error in chaining of 1 in 40,000.

THE EFFICIENCY OF CONCRETE MIXING MACHINES.

By Clarence Coleman, M. Am. Soc. C. E.*

The use of concrete is now so general and is extending so rapidly in various fields of construction that increased efficiency in its manufacture has become a matter worthy of some attention. The objections to machine-mixed concrete have almost disappeared, it being recognized that this material possesses equal advantages with hand-mixed concrete, while for construction work requiring large quantities of concrete the use of mixing machines is almost indispensable. A great variety of concrete-mixing machines are now in use, and the writer has recently made a study of their comparative efficiency. The purpose of the investigation was to deal simply with the economics of the process of mixing concrete by machine. Assuming the use of good cement, stone, sand and water, it was desired to determine the machine which would most economically and effectively mix these materials and produce a concrete of desired consistency, whether wet or dry.

THE NECESSITY OF THOROUGH MIXING.

Thoroughly mixed concrete may be simply stated as a mixture in which all of the aggregates shall be perfectly coated with a film of cement,

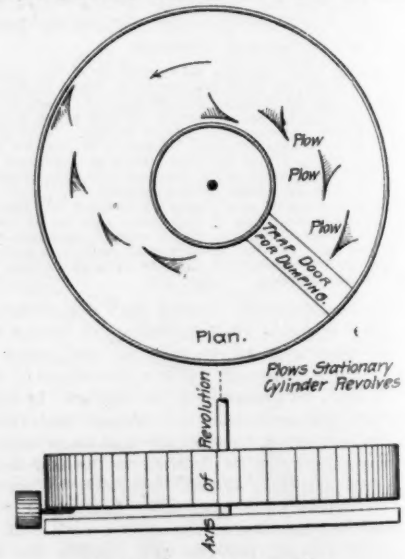


Fig. 3. Pan Concrete Mixer.

and which shall contain a minimum of cement in excess of that which is actually required to coat the particles. The amount of water should be perfectly under control in mixing and should appear in such quantity as may be desired. A machine that will comply with the foregoing conditions with a minimum time factor may be classed

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as a thorough concrete mixer. A machine that fails in any of the requirements stated, is imperfect in direct proportion to the value of the requirement and the degree of the failure.

Cement being the costly element of concrete, it is of the greatest importance that no more than the proper amount should be used, and it would be poor practice to attempt to cover the imperfections of a concrete mixer by using an excess of cement. The amount of cement as determined for any concrete should always be weighed into the batch and never measured; as a volume of cement is a variable. The entire amount of cement should be added to the other aggregates before mixing is commenced and the whole should be mixed dry before the water is added. The determination of the proper amount of water can only be arrived at through good judgment after visual inspection, as the hygrometric condition of the sand is a variable. Hence during the entire process of mixing the mass of materials should be plainly visible to the person who administers the water. The concrete should be mixed in batches as large as practicable for the work in hand, and in mixing, the particles composing a batch should come in such contact one with another as will insure the most perfect and equal distribution of the cement throughout the entire mass.

For the purpose of demonstrating the constructive value of thorough mixing, tests were made by the writer in 1899, to show the effect of varying time of mixing.* It will be seen from Table I. that the time of mixing is a most important factor with relation to the strength of a mortar; or, in other words, time in this case is a synonym of thorough mixing and resulting strength of mortar. Hence we may conclude, that a machine that will produce the greatest possible commingling of its contents in the shortest time introduces an economy in the operation of mixing too important to be neglected.

TABLE I.—Effect of Time of Mixing on Strength of Cement Mortar (1 cement to 3 sand).

Time of mixing.	Water; per cent. of dry ingredients.	Mean tensile strength of briquettes after— Days 7, lbs.	Days 28, lbs.	Mos. 3, lbs.	Mos. 6, lbs.	Years 1, lbs.	Years 2, lbs.
1 min.....	8.25	231.6	317	397	437	435	429
2 mins.....	8.25	274.4	366	425	447	468	430
3 "	8.25	288.2	396	454	516	521	459
4 "	8.25	306.8	418	466	534	536	490
5 "	8.25	324.6	436	495	546	532	515
6 "	8.25	335.0	446	528	554	559	4-1
7 "	8.37	344.8	446	500	569	585	530
8 "	8.50	387.2	471	530	571	563	511
9 "	8.75	362.2	469	533	603	601	530
10 "	8.87	368.6	488	564	612	615	524

The mixing was performed by hand in a cast-iron box with inclined ends, using a hoe almost as wide as the box. Briquettes from the resulting mortar were broken at ages varying from seven days to two years. Each batch for making five briquettes was mixed from one to ten minutes, advancing one minute for each batch. In the briquettes broken after two years, the average increase in tensile strength for the three brands of cement was 20.7% in favor of ten minutes as against one minute for mixing. The results obtained emphasize the fact that thorough mixing is indispensable to the production of good concrete. If this can be effected by machine without sacrifice in time, the first essential step in the efficient machine mixing of concrete has been attained.

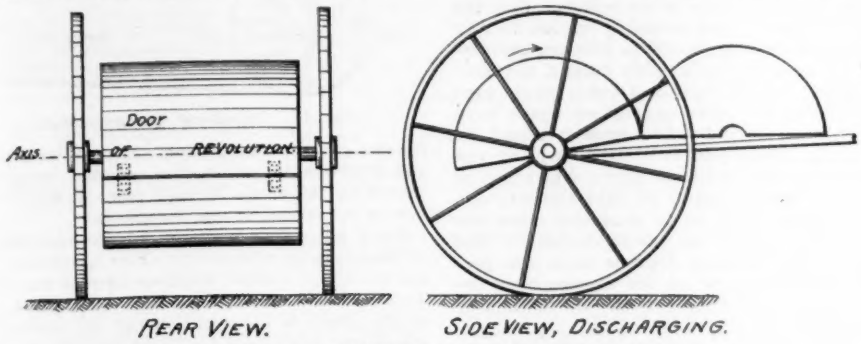

FIG. 4. COMBINED MIXER AND WAGON.

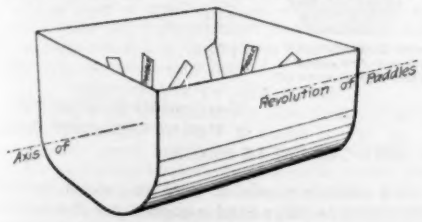

Fig. 5. Trough Concrete Mixer.

*In making these tests three brands of American Portland cement were used, and detailed tables of the results were prepared. We have taken one brand only, as sufficiently indicative of the results, and have condensed the results in the form given in Table No. 1.—Ed.

THE PROPORTION OF WATER IN CONCRETE.

Very small variations in the percentage of water may produce very pronounced results in the strength and gravimetric condition of the finished concrete. Cement is a sensitive substance, with a definite capacity for water in the process of hydration, and either deficiency or excess of water in the operation of mixing concrete handicaps the function of the binding medium in direct proportion to the magnitude of the error. Table II.* shows the effect of excess of water on the tensile strength of cement mortars. The first part of the table shows the strength with the amount of water determined as proper for the given mixture, and also with an excess amount of water. The second part shows the strength of mortars with varying proportions of water. The results indicate that in a concrete-mixing machine the concrete should be exposed to view during the entire process of mixing.

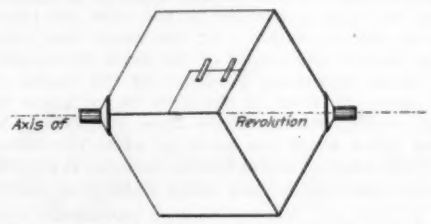

Fig. 6. Cubical Box Concrete Mixer with Door.

TABLE II.—Showing Effect of Proportion of Gaging Water on Cement Mortar.

Mortar.	Water— Proper proportion. Water, %	Strength in days 7, lbs.	28, lbs.	Excess Water, %	Strength in days 7, lbs.	28, lbs.
Neat cement	18.66	715	728	20.83	602	681
1 to 1.....	13.31	492	639	15.00	384	624
1 " 2.....	12.00	390	523	12.37	288	470
1 " 3.....	11.00	229	385	12.50	182	312

Tensile Strength of Mortar: 1 cement to 3 sand.

Water, %	7 days, lbs.	28 days, lbs.	6 mos., lbs.	Water, %	7 days, lbs.	28 days, lbs.	6 mos., lbs.
12.50	168	242	343	8.25	209	246	388
8.25	271	321	437	12.50	127	234	329
7.36	250	308	371	8.25	176	182	251
12.50	158	213	336				

CLASSIFICATION OF MACHINES.

Concrete-mixing machines are of two general types: First, batch mixers; Second, continuous mixers.

BATCH MIXERS.—In this type may be included the following:

(1) A revolving drum or cylinder (with horizontal axis), fitted inside with deflectors, and capable of receiving and discharging a batch without stopping. The concrete is visible during the operation of mixing. Fig. I.

(2) A revolving drum formed by two cones (with horizontal axis), Fig. 2. This also has inside deflectors, can receive and discharge a batch without stopping, and the concrete is visible during mixing.

(3) A revolving circular pan or trough (with vertical axis, Fig. 3). The materials are deposited in the pan, and leveled by means of a fixed spreader. A frame with radial arms carrying a series of plows is lowered into the pan and mixes the materials as the pan revolves. This receives and discharges the batch without stopping, and the concrete is visible during the process of mixing.

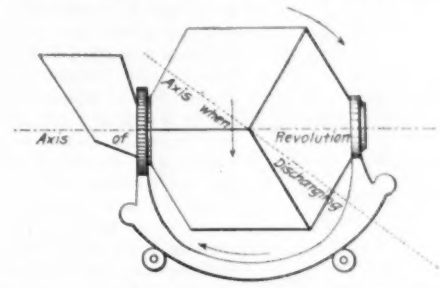

Fig. 7. Cubical Box Concrete Mixer with End Discharge.

(4) A horizontal revolving cylinder which stops to receive and discharge, and mixes the concrete by revolving about its axis. This has been adapted to form a two-wheeled wagon, Fig. 4, the cylinder being revolved by gearing from the axle, so that the batch of concrete may be mixed during transportation. The concrete is concealed during mixing.

(5) A horizontal trough of semi-cylindrical cross section, Fig. 5, with a longitudinal shaft carrying blades. These blades are set at an angle so as not only to mix the material, but also feed the mixture toward the discharge end. The materials are thrown in and concrete discharged without stopping the machine, and the concrete is visible during mixing.

(6) A cubical box revolving about a horizontal axis passing through two diagonally opposite corners of the box, Fig. 6. The materials are introduced through a door in one side, and the concrete is discharged through the same door. The machine stops to receive and dump the batch, and the concrete is not visible during mixing.

(7) A cubical box revolving about a horizontal axis as in No. 6, but having the corners through which this axis passes cut away to form openings for receiving and dumping the batch. The box can be tilted to discharge its load, and need not therefore be stopped for these operations. The concrete is visible during mixing.

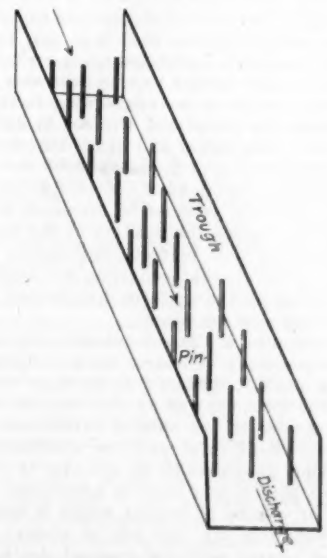

Fig. 8. Gravity Concrete Mixer with Pins.

*Rearranged from a table in the Report of the Chief of Engineers, U. S. Army, 1898.—(Ed.)

CONTINUOUS MIXERS.—Under this class may be included the following:

(8) An inclined chute fitted with pins, Fig. 8. The materials are thrown in at the upper end, and slide down by gravity, being mixed by the continual deflections caused by the pins. The concrete is visible during the process.

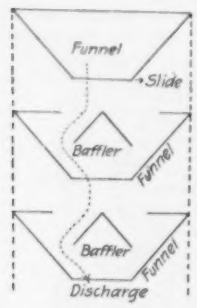

Fig. 9.
Gravity Concrete Mixer with Funnels.

(9) A series of funnels placed one above the other, and having in the wide mouth of each funnel an inverted cone forming a baffler, Fig. 9. The upper funnel is closed by a slide, and forms the hopper for the cement, sand and stone, which are deposited in the order named and followed by the necessary quantity of water. The slide is then withdrawn, and the materials fall by gravity, being mixed during their descent. The concrete is for the most part invisible during the process.

(10) A long inclined box, square in section, revolving on its axis, as in Fig. 10. The materials are thrown in at the upper end, and the concrete is discharged at the lower end, being practically invisible during the process.

(11) This is somewhat similar to No. 10, but the box is of cylindrical form and is fitted with deflectors, as shown in Fig. 11.

(12) An open trough or closed cylinder fitted with a shaft on which are paddles or blades, to mix the concrete and feed it along to the discharge end, as shown in Fig. 12.

COMPARISON OF CONCRETE MIXERS.

Proceeding to consider the two general types of

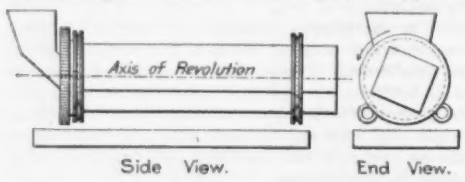

Fig. 10. Elongated Box Concrete Mixer.

concrete mixing machines, it will first be necessary to inquire whether all of the machines above enumerated actually fulfill the requirements for a batch mixer. The fact that a machine receives at one time the materials composing a batch of concrete does not establish it as a batch mixer. To deserve this title there should be a very reasonable certainty that the entire mass has commingled in the process of mixing; that is to say, that the mixing has not been performed along certain lines or planes. It may readily be seen that with a very perfect distribution of the aggregates, fairly good mixing could be performed without bringing all parts of the mass again and again together; but this nice distribution of materials does not obtain in the ordinary operations of concrete mixing, and therefore the machine must be depended upon to so constantly change the position of the particles as to insure the most perfect commingling of the mass, and through that condition accomplish as nearly as possible the uniform distribution of the cement throughout the batch.

With a machine of Class 1, whether the cement is dumped suddenly or poured on the aggregates, there is a decided tendency to produce concrete much richer in cement along the vertical section (at right angles to the axis of revolution) upon which the cement falls, and the distribution of cement along lines parallel to the axis of revolution in this section will vary in proportion to the thickness or volume of cement which is superimposed. That is to say, the pile of cement being dumped or poured with its greatest depth on a line at right angles to the axis of revolution and equally distant from the two end planes of the revolving drum or cylinder, will mix quickly with the stone and sand immediately underlying it, and will be carried very slowly and thinly towards the end of the drum, with the result that the mass of concrete composing the central section as described, will be much richer in cement than the portions of the mass next to the ends of the drum. To insure an equal distribution of the cement in such machines, it has been recommended that the water be put in first, then the cement, and afterwards the other aggregates. In this case the water is made to act as a vehicle for the distribution of the cement. This treatment of cement is, to say the least, of doubtful practice.

The same objections, though in a lesser degree, apply to Class 2. There is no evidence that the mass of concrete being mixed is moved to any great extent in lateral directions between the vertices of the rotating cones. With Class 3, the cement is spread mechanically and quite evenly over the surface of the other aggregates which have been previously spread. The mass is mixed by the rotation of the pan or trough carrying the aggregates against the fixed plows, which are so set as to turn it alternately to right and left, and are also staggered so as to gradually move the mass from one side of the pan to the other. The success of this machine depends upon the perfectly even distribution of the cement over the surface of the other aggregates before the mixing is commenced.

Class 4 has the same restrictions with reference to the lateral movements of the particles as Classes 1 and 2, but in a more marked degree, as it depends simply upon the rotation of a cylinder around a central axis. In Class 5 the mass of aggregates is simply disturbed by the rotation of paddles or arms fixed in a revolving shaft, and there is no evidence that the particles composing a batch of concrete are caused to pass and repass each other in a direction parallel to the axis of revolution.

In Class 6 the planes which constitute the sides of the cubical box act during its revolution in a very positive manner on the aggregates. Each of the six planes acting alternately in one revolution of the cube, serves to throw the concrete from a plane following a curve of ascension against a plane with curve of descension; this change of position with regard to the contents of the cube occurs with each one-sixth revolution of the cube about its axis, and thus the concrete is thrown from one side to another of the cube six times during one revolution. At the same time that those lateral movements of the mass of concrete are being alternately produced by the angles of the planes or sides of the cube to the plane of axial revolution, the whole mass of concrete is being lifted along the plane of axial revolution until the angle of repose for the material is passed, when it gravitates back along lines of direction which intersect the paths of these particles projected by the alternating positions of the sides of the cube in its revolution. Fig. 13 shows the appearance of a cube being rapidly revolved about a diagonal axis. It will be seen that the optical illusion of a curve is produced between these corners which rotate in two vertical planes, by the infinity of change in the positions of the sides or planes of a cube revolving on a diagonal axis.

Assuming a level plane of vision passing through the axis of revolution of a cube, the focus of a plane being equi-distant from the ends of the axis, the six upper diagrams would show consecutive views of a cubical box mixer suspended at its diagonal corners, on a horizontal axis, each diagram showing the two visible sides of the cube

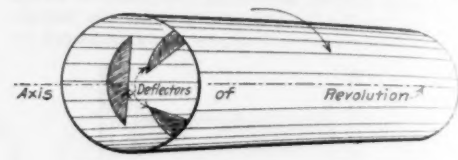

Fig. 11. Cylindrical Concrete Mixer.

for one-sixth of a revolution. The arrows indicate the direction in which the concrete would be moved by the action of each plane or side of the box in the course of one revolution.

Fig. 7 represents a cubical mixer embodying all of the advantages shown for Class 6, and eliminating some very decided disadvantages of that class. In this mixer the concrete is visible during the entire time it is being mixed, and the machine receives and discharges the batch without stopping.

In the continuous machines, as shown in Figs. 8 to 12, the aggregates pass through in a continuous stream without being brought together and mixed as a mass by the machine. This greatly complicates the question of uniformity with the resulting concrete, both as regards the even distribution of the cement and the proper administration of water. It would be useless to compare continuous mixers with batch mixers, as the former fail in respects which the writer advocates as essential in the economic production of good concrete.

Table III. embodies some of the conclusions which this review of methods and machines for mixing concrete has evolved, with reference for

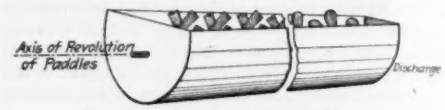

Fig. 12. Trough Concrete Mixer.

types and classes under discussion and their facilities for performing certain functions which are considered important in the manufacture of concrete. The values assigned to these functions though arbitrary are believed to be in accordance with the relative degree of importance of the functions for which they are given. These values could hardly be other than arbitrary, as perhaps no two engineers would hold the same opinion with regard to the values assigned for the various functions. The credits given to continuous mixers in column A are intended to show the relative values of the continuous mixers considered from the function of mixing only; and to compare those values with the perfect value for a batch mixer. In other words it is a comparison of the result of the mixing performed by the continuous

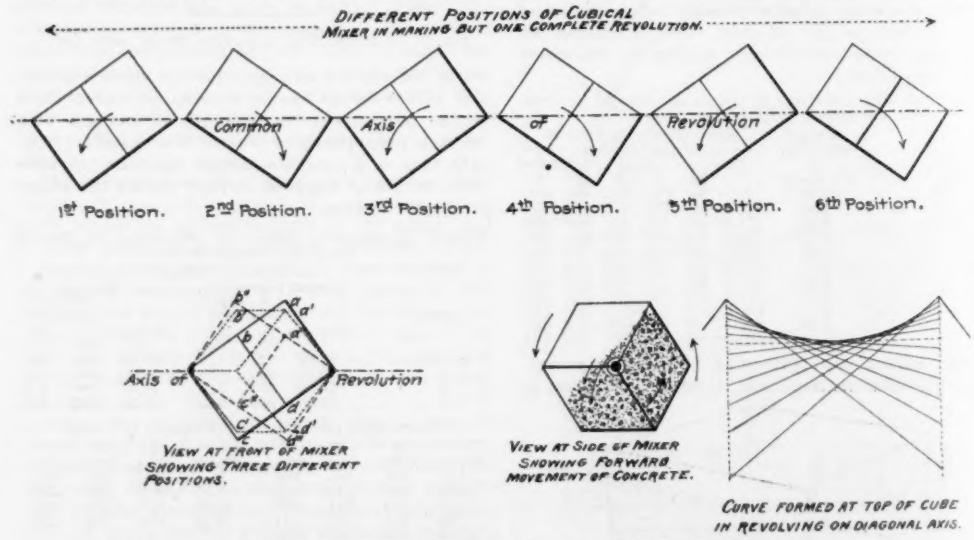

FIG. 13. DIAGRAM OF EFFECT OF CUBICAL BOX CONCRETE MIXER.

machines with the higher values assigned to batch mixing machines on the same work.

The various classes of machines have been considered merely from the point of their ability to perform positively the functions for producing the most perfectly mixed concrete. No comparisons are attempted as to cost of operation, as it can be readily understood that machines of low efficiency and minimum cost of operating can in no way be compared with machines with high efficiency, and higher cost of operating; the great desideratum being always the perfect product. I am very much of the opinion that some machines produce good concrete and others produce bad concrete. If a poor machine is made to produce good concrete through taking sufficient care in the manipulation, then the credit is not properly with the machine, but is due to the manipulation. For instance, a shovel is one of the most perfect mixing machines I have ever had experience with, but the manipulation required is intense. The best machine for practical work is that which will produce good concrete in large quantities with the least time and manipulation.

TABLE III.—Comparison of Efficiency of Concrete Mixers.

	Values for functions.*							
Perfect Class.	40 A.	25 B.	10 C.	5 D.	5 E.	10 F.	5 G.	100 To'l.
Batch 1..	25	25	5	5	5	7	3	75
" 2..	30	25	8	5	5	9	3	85
" 3..	30	25	8	4	5	9	5	86
" 4..	20	5	2	3	4	6	4	44
" 5..	20	25	6	5	4	6	4	70
" 6..	40	5	10	3	3	10	4	75
" 7..	40	25	10	5	5	10	4	99
Cont. 8..	10	5	2	2	3	5	3	30
" 9..	10	3	1	1	4	5	3	27
" 10..	15	12	2	4	4	6	3	46
" 11..	15	12	2	4	4	6	3	46
" 12..	15	25	6	4	4	6	3	63

*Values assigned for perfection in the several functions:

A.—As producing results of a batch mixer	40
B.—For control of water	25
C.—For dry mixing	10
D.—For receiving aggregates	5
E.—For discharging concrete	5
F.—For time in mixing	10
G.—For self cleaning	5
Total value as a mixer	100

THE CATHODE RAY ALTERNATING CURRENT WAVE INDICATOR.*

By Harris J. Ryan, M. Am. Inst. Elec. E.†

During the past three years I have had considerable experience in the use of the Braun type of cathode ray tube to determine the character of rapidly changing electric currents. In this experience I developed the following method for using this form of tube as an alternating current wave indicator. By means of the method this instrument fills much the same sort of a want in the detail study of many alternating current phenomena as does the indicator in the study of the cyclic performance of steam in the steam engine.

I have found the method so convenient and satisfactory in a large class of work compared with other and more usual methods that I am confident that many members of the Institute will find its employment often convenient and most useful in their own work.

DESCRIPTION OF THE METHOD.

The usual form of cathode ray tube employed for indicating alternating currents is shown in Fig. 1. The cathode and anode are connected to the negative and positive conductors respectively of a motor-driven Wimshurst electrostatic machine. A current of about .0005 ampere is set up in so doing and the cathode rays are driven forward through the tube, striking the glass diaphragm which is opaque to them. All of the rays are stopped at this diaphragm except those which pass through a small aperture at its center. This pencil of rays continues until they strike the screen, where they cause a brilliant spot of fluorescent light. The screen is of mica spread with white powder that powerfully fluoresces when struck by the cathode ray.

Comparatively weak magnetic fields will cause large deflections to the ray. Thus if a continuous current be passed through the coils, c', mounted just beyond the diaphragm as shown in Fig. 1, of sufficient strength in regard to the number of turns in the coils so as to produce a m.m.f. of about 50 ampere-turns, the ray will be deflected well to one side of the center of the tube, causing a corresponding displacement of the spot of light on the screen. Such deflection is due to the magnetic field set up across the cathode ray by the current in the coils. When the current ceases the spot of light produced by the ray returns to its normal position. If the current is set up in an opposite direction the spot of light will shift on the screen to the opposite side. When an alternating current having the same maximum value is substituted for the continuous current, the spot of light will vibrate between the two extreme positions, and, owing to the persistence of vision, will appear as a band of light.

By looking at the screen as seen reflected from a revolving mirror the spot of light actuated by an alternating current will trace a wave that will have the same form as the wave of current which is passed through the coils, due to the fact that the cathode ray has no appreciable inertia. Some investigators have revolved the mirror synchronously and thus obtained a stationary wave which is most satisfactory to look at and which may be readily photographed. The synchronous driving and satisfactory adjustment of the revolving mirror involve expensive apparatus that is cumbersome and tedious in manipulation; to avoid the use of this apparatus I have devised the following method:

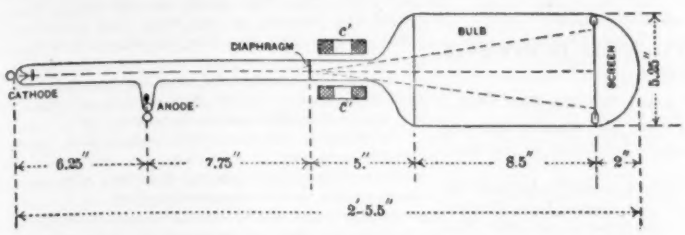

FIG. 1. BRAUN CATHODE-RAY TUBE USED FOR STUDYING ALTERNATING CURRENTS.

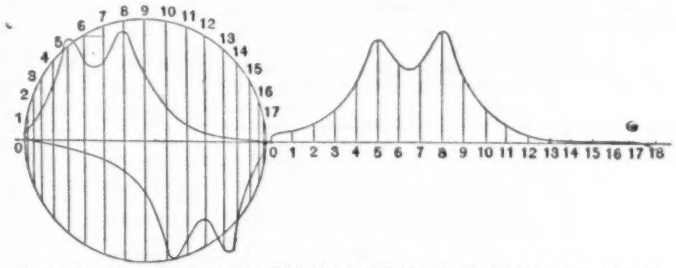

FIG. 5. SMOKED-GLASS TRACING OF E. M. F. WAVE OF OLD T-TOOTHED ARMATURE ALTERNATOR, AND METHOD OF REDUCING TO RECTANGULAR CO-ORDINATES.

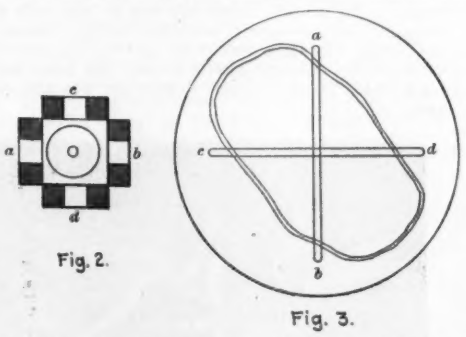

Fig. 2. Fig. 3.

Figs. 2 and 3. Arrangement of Deflecting Coils, and Production of Resultant Current Trace on Screen.

By the following arrangement of inductance and capacity. Referring to Fig. 4, AC are leads from an alternating source of unknown pressure wave-form supplying the current to an apparatus at M that is to be observed. The circuit through M leads through one set of coils mounted at c_1 c_1, so as to give a motion of the cathode ray that is proportional to the instantaneous values of the current through M. The current that produces the standard sine wave motion of the cathode ray tube passes through the coils c_2 c_2 with their axes at right angles and in the same plane of the axis of the coils c_1 c_1. This current is obtained from the source (having an unknown pressure wave form) at a' c'. It passes from c' through the single path L' and the paths C and L'' in multiple, and finally to the source at a'. The coils c_2 c_2 are connected in the branch L''. L' and L'' are inductive reactances made by mounting coils on straight laminated iron cores. The ohmic resistances are made as low as is ordinarily convenient and possible compared with the corresponding values of the reactances. C is an ordinary paper condenser. The reactances of C and L'' are adjusted so as to be approximately equal and, therefore, so that resonance is established to some extent due to the exciting current that is set up through L'. All who have made a study of the characteristic properties or behaviors of the harmonic elements or component irregularities in relation to inductance and capacity will note at a glance the powerful action that this circuit will exert in expurgating the current that passes the branch L'' A c_2 c_2 of all irregularities, causing it to have a simple sine wave form.

I have usually adjusted this circuit so that a current of 0.2 ampere passed L', and 1 ampere circulated through the resonant circuit C L'' A c_2 c_2. Thus arranged the third harmonic will be reduced to one-third compared with the fundamental in passing L'; a further reduction of one-third of the third harmonic occurs through L'', which acts as a throttle for all harmonics while the condenser passes the third harmonics with a facility measured at three times as easy as for the fundamental. A further reduction factor of 5 to 1, acting alike against the third as well as all higher harmonics, is applied by the current multiplying process due to resonance. All current circulated through C L'' A c_2 c_2 due to resonance must have the simple sine form so long as the saturation m.m.f.'s utilized by the iron cores are small compared with those used by the air cores in the magnetic circuit of L''. Thus it is seen that there are approximately the following factors which combine to cut out the third harmonic: $3 \times 3 \times 3 \times 5 = 135$; which means that in the above circuit the value of the third harmonic compared with the fundamental circulating through c_2 c_2 has been reduced to one one hundred thirty-fifth of the original value existing in the e.m.f. wave impressed by the source upon this circuit at a' c'. Since even in very bad cases of wave distortion in e.m.f. generation the third harmonic will not exceed one-third of the magnitude, it follows that the ratio of the fundamental and third harmonic values of the current through c_2 c_2 is about four hundred. Since the higher harmonics are eliminated to a greater extent than the third it follows that the deviation of the current wave through the coils, c_2 c_2, that are to produce the standard known motion of the ray, from the cyclic variation of a true sine wave is less than one-quarter per cent., an accuracy that is ample for the purposes involved.

When the unknown current through M and the coils at c_1 c_1 and the sine wave current through the coils at c_2 c_2 are established at the same time, the spot of light on the screen in the cathode ray tube is given a motion that is the resultant of two motions at right angles to each other and proportional to the instantaneous values of their corresponding currents. Owing to the persistence of vision, this results in the production of a closed card upon the screen traced by the spot of light. A record of this card may be made in various ways. I have generally used one of the two following methods: 1. The card may be easily photographed in the ordinary camera using five seconds exposure, or, 2. It may be traced on a smoked glass mounted in front of the tube by keeping the eye at a fixed point of view. I have generally preferred to record the cards by photographing them.

Ordinarily, the detail of the pressure wave with respect to the current wave that it established is also desired. By means of switches S_1 S_2 and D P D T in Fig. 4, the coils at c_1 c_1 can be disconnected from the circuit a'' M c'' and connected in the circuit with draws current through a non-inductive resistance a''' R c'''. This produces a card due to the pressure of wave-form impressed upon the machine or apparatus at M. Obviously, when the currents through M and R differ widely in mag-

*Slightly condensed from a paper presented before the American Institute of Electrical Engineers at Niagara Falls, N. Y., July, 1903.

†Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.

nitude, an extra set of coils may be mounted concentric with the coils c_1 c_1 through which to receive the current controlled by the non-inductive resistance R. Both cards may be photographed on the same plate, when a true record is obtained of instantaneous values and phase relations of the unknown e.m.f. and current applied at M. To enable the values to be plotted in rectangular coördinates, the axis of the standard or sine wave should also be recorded. This is easily done by removing the current from the coils c_1 c_1 and recording the line of light produced by the sine motion that remains due to the standard current in the coils c_2 c_2.

If a polyphase source is employed it is best to apply the sine wave current through the coils, c_2 c_2, from a

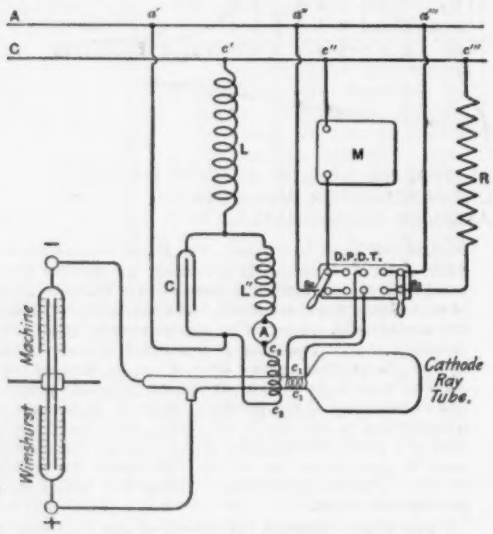

Fig. 4. Arrangement of Apparatus for Obtaining Wave-Form Diagrams.

pressure phase changing device. This is easily and obviously arranged by means of a set of autos having a number of pressure taps or by means of a movable coil mounted in a revolving field such as is provided by every induction motor that has a wound secondary. Thus the phase position of the sine wave can be adjusted so as to cause the more intricate portions of the unknown wave form to occur at the time when the sine wave motion is most rapid, i. e., when the sine wave current is passing through zero. In this manner the resulting cards can be so adjusted as to bring out the desired detail to the fullest and clearest extent.

In a simple and obvious manner the values of the unknown wave may be taken from its card and plotted with time in rectangular coördinates. One way of doing this is illustrated in Fig. 5. A circle is drawn using the sine wave as a diameter. Upon this circle a number of equidistant points are located corresponding to the number of points to be used in plotting the wave in rectangular coördinates. Ordinates to the sine wave diameter of this circle will intercept the card at uniform time intervals. The lengths of the ordinates from the card to the diameter are proportional to corresponding instantaneous values of the wave and may be transferred without change to the rectangular diagram to form the actual wave as shown in Fig. 5.

The scale that applies to the instantaneous values is determined by comparing the effective value of the observed wave with the reading of an alternating current ammeter placed in series with the sine wave coils, c_2 c_2. This ammeter is read at the time that the card formed by the unknown wave is recorded. The ratio between the deflections of the ray produced by the coils c_1 c_1 and c_2 c_2 is easily obtained once for all by means of observations taken with continuous currents and instruments.

The half tone in Fig. 6 was made from a photograph of a set of cards and their axes as they were formed on the screen of the cathode ray tube. In making these cards the method was being employed in a study of the conductivity of the atmosphere about a line conductor subjected to high pressure. The card L C was formed by the line-charging current and the card C C by the charging current supplied to an air condenser for the purpose of determining the e.m.f. wave impressed upon the line. The coils corresponding to c_1 c_1 in Fig. 4 in this instance contained a total of 46,000 turns which would enable cards to be formed with currents of from .0006 to .006 ampere, i. e., from .6 to 6 milliamperes. The effective e.m.f. employed was 40,000 volts at 120 cycles. The exposure was of such length that the card represents the superposed trace of about 1,300 cycles.

I think that this apparatus will in the future be found of use in observing the behavior of hunting currents in synchronous machinery, commutation in continuous current machinery, the characteristic manner of current interruption produced by fuse cut-outs, and circuit breakers and electric surges on long lines.

As was shown above, it is easily applied where cyclic phenomena are to be observed. It can, however, frequently be used effectively for observing values that occur only as sudden impulses, by having the current constituting the sudden impulse through one circuit and a uniformly increasing current through another circuit occur simultaneously and arranged so as to act magnetically upon the cathode ray. A momentary trace showing the nature of the impulse is thus drawn across the fluorescent screen.

CLEANING A LARGE BRICK SEWER IN HARTFORD, CONN.*

By Frederick L. Ford,† Assoc. M. Am. Soc. C. E.

During 1902 considerable work was done in cleaning the Franklin Ave. sewer, one of the largest in the Hartford sewerage system.

The sewerage system of Hartford is wholly built on the combined plan, and consists at the present time of about 87 miles of main tile and brick sewers, all built since 1844, the date of the first sewer in Hartford. Most of the sewers have sufficient grade to produce self-cleaning velocities.

The Franklin Ave. sewer cleaned consists of 9,269 lin. ft. of circular brick sewer, 5,128 ft. of which is 6 ft. inside diameter; 2,225 ft., 4 ft.; and 1,916 ft., 3 ft. inside diameter. This sewer was built in 1872-73, at a cost of about $150,000, and drains a district containing about 1,167 acres. It has never been thoroughly cleaned since it was built. The sewers which discharge into this trunk sewer vary from 8 ins. to 3 ft. in diameter, and have grades ranging from 0.5 to 6.0 ft. per hundred. The 6-ft. Franklin Ave. sewer has a grade of 2 ft. per 1,000, and the 4 and 3-ft. sections a grade of 3 ft. per 1,000.

This trunk sewer, although considered entirely too large at the time it was built, is now hardly sufficient to provide for all the water collected during severe storms, and considerable difficulty is experienced by the flooding of cellars and basements adjacent to this large sewer. This condition has come from the rapid growth of the district and the gradual change of a large part of the district from an absorptive to an impervious surface.

On account of the congested condition of this sewer, we started some experiments the past season to determine the location and extent of the nuisance, and also to measure the amount of water passing off from this district during severe rain storms. It was during the organization of this work we discovered the serious condition of this sewer. The first work done was a thorough inspection of the sewer to determine the location and amount of the deposits. In the 6-ft. sewer this was an easy task with lanterns, and the material was found only in patches on the bottom, averaging from 6 ins. to 1 ft. deep and from 50 to 150 ft. in length, located usually just below where some large tributary sewer entered the Franklin Ave. sewer.

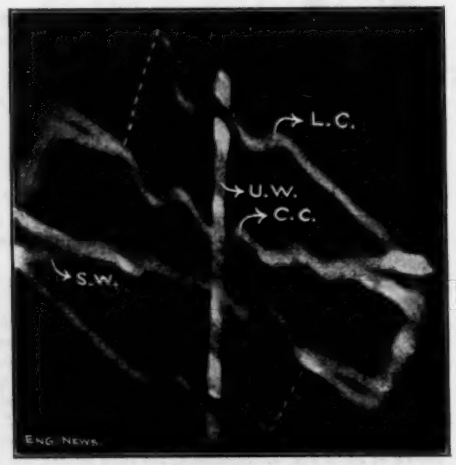

Fig. 6. Photographic Record of Current and Voltage on High-Potential Line Conductor.

S W = Trace of Standard Line-Wave Current.

U W = Axis of Diagram of Unknown Wave Form.

C C = Trace of Line E. M. F. (represented by condenser charging current).

L C = Trace of Line Current.

It was impossible to make a thorough advance inspection of either the 4 or 3-ft. sections of the sewer, as the manholes were, as originally built, sometimes 1,000 ft. apart, and the ventilation so bad that we found it suffocating and too dangerous to enter either for any great distance from any manhole.

The deposits in the 3-ft. sewer were found, upon opening the sewer, to average about 1 ft. in depth and the ordinary sewage, about 6 to 8 ins., was running on top of it, so there was little available working space left.

As the magnitude of this work was a very indeterminate quantity, it was decided best to engage a competent sewer contractor to furnish all materials and labor and superintend the cleaning on a 15% basis. He selected a foreman at $15 per week, and for laborers some trustworthy Italians, who, from their small size and rugged constitution, were best adapted for this work, and paid them $2 per day, 50 cts. more than they ordinarily received on sewer work.

Before commencing the cleaning, manholes were built where necessary, so that they are now not more than 600 ft. apart, and often less on the smaller sizes.

In cleaning, the force was organized in small gangs, which could work to advantage; two starting in at a manhole and working in opposite directions until they met the men coming in the opposite direction.

In the 6 and 4-ft. sections, wheelbarrows were used to convey the material removed to the nearest manhole, where it was hauled up and removed in carts, each holding 1 cu. yd. In the 3-ft. sewer the men used pails to remove the deposit.

The result of the work is as follows:

Diam.	Length, ft.	Loads, or cu ft.	Cost—Total.	Cost—Per cu. ft.	Cost—Per lin. ft.
6 ft.	5,128	107	$388	$3.62	$0.075
4 ft.	2,225	61	244	3.99	0.109
3 ft.	1,916	107	466	4.36	0.243
Total	9,269	275	$1.098	.....	.....

The 6-ft. sewer was cleaned in 7 days. The total time on this work, including foreman and team, was 1,592 hours. This is equivalent to 22.7 men working 10 hours a day for 7 days.

The 4-ft. sewer was cleaned in 4 days. The total time was 1,000 hours, equal to 25 men employed 10 hours a day for 4 days.

The 3-ft. sewer was cleaned in 13 days. The time occupied was 2,019 hours, or an average of 15.3 men, working 10 hours a day for 13 days.

The average distance cleaned by each man per day on the 6-ft. sewer was 32 ft.; on the 4 ft. sewer, 22 ft., and on the 3-ft. sewer, 9 ft.

The total cost of the work, including manholes built, was $1,395, of which 15% was paid to Mr. Charles H. Slocomb, who furnished the labor and materials and superintended the work.

*Slightly condensed from the Bulletin of the Connecticut Society of Civil Engineers.

†City Engineer, Hartford, Conn.

USE OF MINERAL OIL IN ROAD IMPROVEMENT.*

By James W. Abbott.†

Public attention was first called to the utility of crude petroleum oil in road betterment through experiments made by the county of Los Angeles in California in 1898, where six miles of road were oiled in that year under the direction of the supervisors. The sole purpose of this work was to lay the dust, which, churned beneath the wheels of yearly increasing travel during the long dry seasons in that region, had become a most serious nuisance.

The following year this mileage was a little more than doubled in that county, and other counties in California also began experiments along the same line.

From the very first the results obtained were so astonishingly successful that the practice rapidly increased. After five seasons, it has extended from near the Mexican line, on the south, to Durham, in Butte Co., on the north, a stretch covering sections of quite widely differing climatic conditions, with an aggregate of about 750 miles of county roads and city streets oiled for one or more years. Oil has been used on the principal driveways of Golden Gate Park, San Francisco. The mountain stage road into the Yosemite National Park has been oiled for a distance of 30 miles, from its initial terminus at Raymond to eight miles above Wawona.

It has been tried to a very limited extent in Texas, and a few isolated experiments have been made in Pennsylvania, New Jersey, Indiana, Colorado, and the District of Columbia. Within the past year also a few experiments have been reported from England, France, and Switzerland.

As already stated, the original motive for the use of crude oil on roads was to lay the dust. Wherever oil has been tried this purpose has invariably been accomplished, regardless of methods adopted or variety of oil used. On all kinds of roads where it has been applied the dust has ceased absolutely for at least an entire season after its application, and if renewed a second year has been abated for that year also and the following, whether then treated or not. In southern California all unite in saying that the great bane of life—dust—passed away wherever the first application of oil was made. The dust raised by passing travel no longer comes in at windows or destroys

*Slightly condensed from Yearbook of Department of Agriculture for 1902. There are a number of illustrations in the original, which has been reprinted in pamphlet form.—Ed.

†Special Agent, Rocky Mountain and Pacific Coast Division, Office of Public Road Inquiries, Washington, D. C.

the products of field and orchard for considerable widths on each side of the road, as it formerly did.

BENEFITS.—In California it was soon learned that when oil was applied it immediately began to bind together all the loose particles constituting the road surface, whether clay, sandy loam, loose sand, gravel, or the fine material on the top of the macadam. A tough stratum formed, resembling an asphalt pavement. Roads built on drifting sand or clayey dust, no matter how deep, where trotting with a buggy was impossible and for a pair of strong horses to pull a ton was a very laborious process, became indurated, resilient, and firm, so that driving teams could trot with ease and the same pair of horses pull 2½ tons more comfortably than they formerly did one ton. Of course, these results were not fully obtained immediately, but they never failed to follow persistent treatment with oil.

Running south from the railroad track in the town of Chino, San Bernardino Co., Cal., is a piece of road over which every season nearly 40,000 tons of sugar beets are hauled on their way to the factory, often averaging 750 tons a day. The foundation of this road is a loose sand, and it has been surfaced with a material containing some clay. Formerly the loaded wagons often stalled and had to be dug out. Now, after three seasons of treatment with oil, the road is as easy to drive over as a good city street, and effectually sustains the heavy travel, although the majority of the wagons used on it have narrow tires.

In another place in the same county, several miles distant from the one just described, the road runs over drifting sand just like the worst to be found on Cape Cod, in Massachusetts. It has been treated for two seasons with oil, and is now equally as good as the other. Both pieces of road were visited and carefully examined by the writer, who can testify to the almost incredibly satisfactory results obtained.

EFFECTS OF SEVERE RAINFALLS.—All semiarid regions are subject to very heavy rainfalls at times, which are generally called waterspouts. In California these have in many places subjected oiled road surfaces to the severest possible tests. Mr. Theo. F. White, a civil engineer, one of the supervisors of San Bernardino County, a man who has had a great deal of experience in oiled roads and made them a special study, tells of one storm occurring in that county in which 10½ ins. of rain fell, 6 ins. of it in a single night. He says:

> The whole country was flooded and it gave us a good test of our oiled roads. There is a road running into San Bernardino on a grade of about 6%, about 300 or 400 ft. from a bench down into a creek bottom. The road had been oiled a second season and there was a good oiled surface. The water rushed down the middle of that road, because the ditches could not carry such a great volume of it, and it did not make a scratch on the road, but a half mile south there was a road of about the same grade which was so badly washed that it could not be used until it was repaired—a road that was not oiled. Between Pomona and Freeman there was a great quantity of water came from a canyon and struck the oiled road at right angles at one point. It came from the west, and on the east side of that road there was a margin of 6 or 8 ins. of the surfacing material that the oil had not touched. The rain passed over the oiled surface, and when it came to that which was not oiled it cut it right out. Upon the same road within the city limits of Pomona the road was surfaced with decomposed granite, packed down hard, and a very nice road during the summer, but it had not been oiled. The same storm cut it all to pieces. On one stretch of a quarter of a mile the road material was fairly washed out into the fields alongside the road.

THEORETICAL OBJECTIONS.—When they first began to use oil on roads in California there was much speculation as to whether it would not be found objectionable; but when properly applied, and suitable precautions were taken not to use the road before it was ready, the theoretical objections vanished. When oil was placed upon the surface of the road, if vehicles were allowed to run over it before it had sunk in and become thoroughly incorporated with the road material the wheels picked up the oil and threw it in all directions, injuring clothing and everything else of a delicate nature upon which it fell. After experience had taught how to avoid this, no further serious difficulties manifested themselves.

The mud from oil-treated roads, after the oil has become thoroughly diffused through the material, does not appear to be more objectionable than ordinary mud.

Diligent inquiries about the effect of oiled roads on rubber tires failed to disclose any complaints, except in cases where the tire had come in direct contact with the oil.

For a short time after oil is applied there is a very perceptible odor, which soon disappears almost entirely. While it lasts it is not essentially disagreeable.

COMPOSITION OF CRUDE PETROLEUM OILS.—The chemical composition and character of crude petroleum oils vary greatly in the different localities where the oils are found. They are all complex hydrocarbon compounds. The more carbon they contain the greater their specific gravity and the higher the temperature required to evaporate them. The petroleums of Russia belong generally to what is known as the naphthene series. Those of Pennsylvania, Ohio, Colorado, and Wyoming have a paraffin base, and those of California and Texas have an asphalt base.

All petroleums will lay dust, but asphalt is required to bind together the loose particles of a road surface.

The very heaviest of the oils have almost the specific gravity of water, while a naphtha may be 75° B., or even lighter.

From the very beginning of the use of crude oil for roads in California it seems to have been understood that it was the asphalt in the oil which acted as the binder, and consequently they have always sought very heavy oils for that purpose. It might naturally be supposed that the heavier the oil the greater the percentage of asphalt. While this is approximately true, it does not necessarily follow. A crude oil is a complex mixture of light and heavy hydrocarbons, and its resultant gravity depends upon the amount of each kind which it contains.

The following was compiled from the notes of eleven analyses of crude oils made in California by D. B. W. Alexander, now the Denver chemist of the Colorado Paving Co. The original determinations covered many other data, but in the table only the degrees Baumé and the percentage of asphalt are shown:

°B.	Per cent. asphalt.	°B.	Per cent. asphalt.	°B.	Per cent. asphalt.
10.4	64.1	15.4	32.1	19.3	32.8
12.2	45.0	15.5	50.2	23.0	25.4
13.0	61.0	15.7	39.9	23.0	43.0
13.75	59.0	19.0	28.0	....	....

All of these oils doubtless contained a small amount of mineral matter which affected the specific gravity and disturbed the relation between it and the asphalt contained.

The above table shows that in selecting a petroleum for road purposes the specific gravity alone is not a sure guide. It also shows that the California practice of selecting an oil of 12° B. to 14° B. can be depended upon for good results.

Mr. L. B. De Camp, of San Francisco, suggests the following as a crude test used by him; it is probably closer than the Baumé measurement:

> Pour a definite amount of crude petroleum into a graduated glass and add an equal amount of refined petroleum. Stir thoroughly together and add to the mixture 2% of commercial sulphuric acid. Again stir thoroughly and the asphalt will precipitate to the bottom. The percentage which it represents of the original amount of oil can be measured by the graduations on the glass.

OILS USED ON ROADS.—Instead of crude oil, asphalt residuums, from which the lighter products have been distilled, have been much used on roads in California, but no observations have been made to determine whether the results have been more satisfactory in proportion to the amounts used.

Texas oils carry on an average a much lighter percentage of asphalts than California oils.

In the few experiments made with oils on roads in the United States outside of California and Texas a residuum from paraffin crude oils has generally been used of about 26° B. While these experiments have always been successful in laying dust, they have not been followed up with sufficient persistency to demonstrate any efficacy of this material as a road maker.

METHODS OF APPLICATION.—For a time it was quite strenuously argued by many that it was the better practice to apply the oil to a road surface while it was moist like an orchard soil, when it works well. It was contended that the water and the lighter oils evaporating together would effect a more desirable result than could be secured without water. This view is now unanimously rejected by all experts in road oiling. While all agree in advocating liberal sprinkling in preparing the road surface, the aim is to let the water all evaporate before the oil is applied.

There has been a very spirited controversy over the question, "Must oil be artificially heated to produce the best results?" Until within the past year the majority of the practical oiled road makers insisted that it must; but experience with oil at normal temperature (always spoken of as "cold oil") has resulted in increasing the number of those who advocate doing away with heating devices. It is universally conceded that the hotter the oil can be applied the more quickly it becomes absorbed and incorporated with the road material. Heat thins the oil and increases its tendency to penetrate a firm road covering.

The principal argument against heating is its cost. It requires special apparatus, and the process involves some expense. If the heating apparatus is stationary, the oil must go to it to be heated and hauled from it onto the road treated, no mater how far away.

These stationary heating plants have always been erected at some railroad siding. If possible a siding has been selected above the general surface. A receiving tank, large enough to hold the contents of one tank car, was placed beside the track, low enough so that oil from the car would run into it by gravity. A heating tank was then placed above the receiving tank, and at sufficient elevation so that the heated oil would run by gravity into the distributing tank wagons. A stationary boiler was installed to force steam at high pressure through steam coils in the heating tank, from which the steam exhausted into a feed-water tank. A pump to raise oil from the receiving tank to the heating tank, a feed pump, and a structure to house everything in, completed the installation. The first cost of such a plant was between $1,000 and $1,500.

At Golden Gate Park, in San Francisco, Superintendent John McLaren uses two distributing tank wagons of 650 gallons each, which are both equipped with steam coils, so that the oil in one can be heated while the other is distributing. Steam from the boiler at the pumping station is used. Of course, this necessitates hauling the oil to this point to be heated. In some places a portable traction engine has been used. This, with coils in the distributing tanks, allows the oil to be delivered by the cars at the siding nearest where the work is being done, and reduces the heating cost to a minimum. But the tendency in oiled-road practice is toward relying for heat upon the sun only.

PREPARATION OF THE ROAD.—When a road is to be treated it must first be prepared to receive the oil. It should receive a crown of about ½-in. per ft. Careful attention should be given to the drainage. The oil covering when finally made will be impervious to water, but if the foundation is water soaked it loses its firmness and ability to support the road surface under travel, and causes it to break through in spots.

After the road has been properly shaped it should be given a thorough soaking with a road sprinkler and rolled with a light roller. The purpose of this is to insure uniform consistency and a firm foundation. It should then be left undisturbed, if possible, until the water dries out. Many roads have been oiled and excellent results obtained without any wetting or rolling, but the practice described is the best where the facilities are obtainable.

A soil which after being wet tends under travel to pack firmly, but is still sufficiently porous to let water drain through, is ideal for treatment with oil. A clay that bakes and then pulverizes into fine dust under the wheels will only give good results when some material is added, as explained later.

After the road surface has become dry it is well, if feasible, to run a sharp-toothed harrow over it, so as to loosen it to a depth of 3 ins. The aim is to secure an oil crust 3 ins. thick. If the road surface can be made to absorb oil to that depth, that is the simplest way to get the crust. If this surface is hard and will not readily yield to the harrow for a depth of 3 ins., the practice is to build it up by adding material after the oil is applied.

If travel can be kept entirely off the road, then the full width should be finished before vehicles are allowed on it. If that is impossible, then a strip at a time must be treated, and travel meanwhile confined to the other strip.

APPLYING OIL.—The oil is put on by means of a longitudinal tank and a sprinkler, mounted on wheels. Attempts have been made to use an ordinary sprinkling wagon, but with very poor success. When the tank was full it would discharge much faster than when it was partly full. There was a tendency also for the center of the strip treated to get too much oil and the edges not enough. If hot oil was used, the spray tended to cool it before it reached the ground.

In what is known as the De Camp machine the distributer proper is mounted on separate wheels and coupled to the rear of the tank wagon, the slip tongue being removed. The oil runs from the tank through a flexible hose. It has an oil reservoir and three sets of fingers. The first set makes furrows just ahead of the oil-discharging pipes. The second set of fingers (or curved teeth) covers up the oil, and the third set stirs up the combination of oil and dirt. There is also a drag to crush any globules or chunks which may tend to form. When the oil is being distributed the second and third sets of fingers and the drag are raised from the ground by hooks. After the oil is distributed this machine is detached from the tank, the slip tongue put in, and the machine dragged back and forth over the oiled road until the oil has been thoroughly incorporated with the road material.

In other distributers, like the White and the Glover, the oil is conducted from the tank by a forked tube into a large-bore pipe about 6 ft. long, so attached to the framework of the wagon that it hangs crosswise of it and about 6 ins. above the ground, just behind the rear wheels. This pipe has a number of openings on its underside through which oil can run out. These openings are uniform distances apart, in sets, and all controlled by valves which can be opened either by the driver or by a man who has a seat for the purpose on the rear of the tank.

The next process is to stir up the newly-oiled surface and work the oil and road material together. How this is done with the De Camp machine has already been described. Other ways are as follows: A sharp-toothed harrow, preferably the ordinary steel-lever kind, with the teeth slanted back, is dragged along and then across the road until further stirring is unnecessary. In Golden Gate Park men follow the distributer with rakes and stir the material entirely by hand. Special machines called "stirrers," to be drawn by horses, are made, in which the teeth have an oscillating or cross motion when the machine is being pulled forward. Another machine, which is said to be especially valuable when the ground is cold or wet, is the Fitzgerald roller, provided with alternating rows of inch-square steel prongs 6 ins. long.

If after the stirring process some spots appear sticky and others dusty, it shows too much or not enough oil. Over the sticky places should be thrown some of the unoiled road material and this stirred in with a hand rake. The dusty spots must be treated with more oil and stirred. The whole work should show uniform results.

After 24 or 48 hours the road can be traveled over.

SANDING THE ROAD.—The practice above described is that followed when the road material is sufficient porous for oil to readily mix with it. If it is hard, like baked clay or macadam, and cannot be readily stirred, the oil must be put on when the road surface has been heated as much as possible by the sun. If the oil itself can be first heated, so much the better. In fact, the more heat there is in the oil, the ground, and the atmosphere when oil is applied, the quicker the results obtained, whatever process is used. Some of the oil will sink into the hard covering; the rest will remain upon the surface and must receive a coating of sand or fine gravel. The oiled crust which results from such treatment will be partially the top surface of the

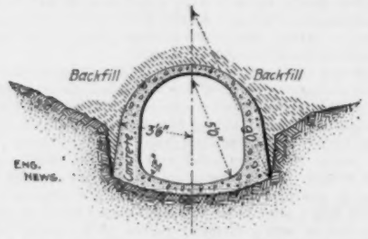

Fig. 1. Cross-Section of Concrete Water Supply Conduit, Los Angeles, Cal.

original road and partially the new envelope. This can be still further built up by another oiling and another layer of sand. This sand (of fine gravel or quite sandy loam) can be applied with a shovel by a man who rides on a load of sand driven besides the oiled strip. Practice will bring considerable dexterity in throwing out sand in thin strips with a shovel.

The White sanding machine is a device for spreading the sand more uniformly. It consists essentially of a hopper and a corrugated drum mounted on an axle on two wheels and with a castor wheel in front. The sand falls onto the drum and runs out in a sheet whose thickness is regulated by appropriate mechanism. In practice, it is attached by a sort of triangular bracket to a wagon loaded with sand, carrying two men facing each other, who shovel the sand into the hopper. The wagon runs beside the oiled strip. The hopper runs on the sheet of sand which has fallen from it.

After an oil road has been traveled a few weeks it is an advantage to roll it with a light roller; but the best rolling effect is obtained if as soon as travel begins on the newly oiled road a wagon is used with broad tires (at least 6 ins.), with front axle shorter than the rear by an amount nearly equal to double the width of the tire.

QUANTITY OF OIL REQUIRED.—In California, where the aim is to always use an oil containing as much asphalt as possible, the amount of oil required for a 16-ft. roadway varies between 250 and 400 barrels of 42 gallons each to the mile. This depends upon the thickness of the oil crust made, the porosity of the material, and the percentage of asphalt in the oil.

The quicker this oil crust is made the better. If two applications are made to a porous material and the oil properly stirred in each time, the crust will be finished. If the hard material is a clay, it should have at least two treatments. One will be sufficient for macadam. A dusty clay will require some gravel added for the first application. On the second application the crust which has begun to form should not be disturbed, but after all the oil sinks in that will a layer of sand should be sprinkled on top. In this oiled crust the bottom will be made from the clay dust and the top mostly from the added sand, while the middle will be a mixture of the two.

After the oiled crust has once been properly formed all the oil required will not exceed 25 barrels to the mile for repairs in each subsequent year.

The view (not reproduced—Ed.) shows oiled crusts taken from three oiled roads in Chino, San Bernardino county, Cal., where a different practice was followed in each case. In all the substratum was a loose, sandy loam sand predominating. All the roads were formerly very dusty, loose, and full of "chuck holes" in the dry season, making the hauling of heavy loads extremely difficult and driving disagreeable. The sandy substratum, as shown in the blocks, has become compacted under the firm oiled crust. Designating the roads by the numbers of the samples, No. 1 was surfaced with a clayey gravel, which always binds well. It was first treated in the summer of 1899, and subsequently in 1900 and 1901, but not at all in 1902. The amounts of oil applied were 120 barrels the first year, 80 barrels the second, and 40 barrels the third. The width treated was a little in excess of 16 ft. The crust is a little over 1 in. thick. In No. 2 the oil was applied directly to the loose roadbed, without any expectation of benefit except to lay the dust. It was oiled the same years as No. 1, with 100 barrels, 120 barrels, and 80 barrels, respectively. It began to compact the second season, and since the third season has averaged about 2 ins. thick. It is an excellent, firm road. No. 3 was formed during the season of 1902, with two oilings of 150 and 100 barrels, applied at an interval of about eight weeks. It will average somewhat over 2 ins. in thickness, and is the best road of the three.

REPAIRS TO OILED ROADS.—If the crust gets broken it should be repaired at once. For winter repairs it is well to mix in the fall a lot of sharp sand or fine gravel with oil, stirring it all up with a hoe in a mortar box as mortar is mixed, and being careful not to put on so much oil that any will run away when the mixture is left standing. When a hole starts, clean it out thoroughly with a hoe or brush broom, fill the hole to a little above the adjoining surface with some of the oil and sand mixture, and thoroughly ram it.

Most of the distributers which are now made have a short hose attachment, with gate and nozzle and shut-off valve for use in repairs. When a patch appears to have too little oil, or a hole needs repairs and no oil mixture is at hand, a little oil can with this hose be put just where most needed, and with a rake, hoe, shovel, and rammer the difficulty is quickly remedied.

It frequently happens that travel follows the same track, and the narrow tires and feet of the horses wear depressions. It is important to correct these and reshape the road at least once a year. It has been found that an ordinary blade road grader will not do this successfully, but will tear up the oiled crust and destroy it. The White smoother is a device for shaving off elevations and filling up depressions in an oiled crust. It consists of a pair of runners 16 ft. long and 4 ft. apart. Between them, at the front end, are set on a slant backward obliquely to the left three rows of ¾-in. steel harrow teeth, so adjusted that they shave along lines just 1 in. apart. As their edges get dull the teeth can receive a quarter or half turn and their height from the ground can be regulated. There is also a blade set obliquely which scrapes off the shavings made by the harrow teeth. These shavings, confined by the two runners and the blade, naturally seek the depressions. In the left-hand runner is an opening, through which any surplus shavings are forced out toward the center of the road, thus tending to raise the crown. There are wheels on the sides upon which the machine, with runners raised from the ground, travels when being moved from one place to another, and a steering gear by means of which the operator readily controls its direction. A road reshaped with this machine, treated with a light sprinkling of oil and a thin sheet of sand and rolled, resembles a city asphalt street when first laid.

CONCLUSION.—The question will naturally be asked, "Where can oiled roads be made to advantage outside of California and Texas?" The answer certainly must be, any place in the United States where, through long, hot, dry summers the roads become very dusty and where water can be kept out of their foundations in the winter, so that they will remain firm and not give way beneath the oiled surface in the spring. The reliance must be upon an oil with an asphalt base, whether it comes from California or Texas or is made by dissolving an asphalt in the crude oil of any section, all of them being solvents for asphalt. The gilsonites of Utah and Colorado, the asphalt deposits of Indiana, Arkansas, Indian Territory, and probably other localities, will all doubtless yield a product that can be combined with the paraffin crude petroleums for road purposes. The cost will of course be much higher than in California, where they have been accustomed to buy their heavy oils for a dollar a barrel and sometimes cheaper, but compared with the cost of stone-covered roads it will be found to be less and in a very dry climate the results fully as good. Where the purpose is only to mitigate the dust any crude oil or its residuum will be found efficacious.

Note.—The writer requests that cordial thanks and appreciation for services rendered in the preparation of this paper be expressed to Messrs. A. S. Cooper, L. B. DeCamp, John McLaren, and H. A. Mason, of San Francisco, Cal.; A. E. Burns, C. B. Boothe, O. W. Longden, and F. W. Mattern, of Los Angeles, Cal.; Theo. F. White, of Chino, Cal.; J. B. Glover, of Redlands, Cal.; N. V. Nelson and Hugh McGuire, of Marysville, Cal.; E. J. White, of Yuba City, Cal.; W. E. Coman, of Portland, Ore.; James H. Nichol, of Camden, N. J.; D. W. B. Alexander, of Denver, Colo., and N. L. Taylor, of Tacoma, Wash.

CONCRETE WATER SUPPLY CONDUIT AT LOS ANGELES, CAL.

By Wm. Mulholland.*

The accompanying section and view show the main features of a concrete water-works conduit now under construction by the city of Los Angeles. The conduit will have a length of 40,600 ft., of which about 7,000 ft. had been built on Aug. 1. It is of monolithic construction in situ, with a grade of 2.64 ft. to the mile. The various dimensions are given in Fig. 1. The inside of the conduit is smoothly plastered.

The concrete is composed of 27 cu. ft. of broken stone, 8 cu. ft. of sharp sand, and one barrel of cement. The stone is obtained from a granite quarry about a mile from the upper end of the conduit.

The capacity of the conduit, as designed, is about 50 cu. ft. per sec., or some 32,000,000 gallons a day. The conduit will connect the new infiltration gallery on the margin of the Los Angeles River with the distributing reservoirs of the water-works.

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A PECULIAR PLATING PROCESS is being employed in Germany to produce sheet-metal consisting of several layers of different metals. The process utilizes the adhesive qualities of aluminum at moderate heat. A typical product is a sheet of iron (soft steel) coated on both sides with copper, the completed sheet having about 15% of copper. Such sheets can be used as a roof-covering, either plain or corrugated, in place of copper on wood, or in place of galvanized iron. The process of making such plates is as follows: A copper plate is cleaned and roughened by sand blast, and is then rubbed over with a piece of aluminum, which forms a thin partial coating of aluminum on the copper. A thin sheet of aluminum is then laid on the prepared copper plate, the two are heated to about 800° C., and then passed through the rolls and rolled out into a thin sheet of copper having an aluminum plating on one side. By laying two such sheets, aluminum side down, on the two sides of a clean iron plate, and heating to about 400° C. in a muffle furnace, the sheets may be rolled together and a partial adhesion secured. The combined sheet is then heated to a higher heat, about 800° C., and rolled out to the desired thickness, a perfect adhesion being thereby secured between the iron and the copper by virtue of the layer of aluminum between them. Other combinations than this one are produced in the same general way; examples are copper-aluminum sheets, copper-aluminum-copper, steel (soft steel) coated with aluminum on one or both sides, or an aluminum core coated with steel, combinations of copper and zinc, of aluminum and zinc, or of all three metals, etc. The process is the invention of Mr. H. Wachwitz, of Nürnberg, and is being exploited by the German Wachwitzmetal Co., of Hersbruck, Germany.

A CONSOLIDATION SUBURBAN TANK ENGINE has been built by the Great Northern Ry. of England, to handle the very heavy suburban traffic in the neighborhood of London. The eight coupled driving wheels are under the boiler, while the truck (which is really a radial axle) is under the bunker at the rear. With 160 lbs. cylinder pressure the tractive effort is about 30,000 lbs., or sufficient to give an acceleration of 1½ ft. per second with a train load of 230 tons, on the level. Thus a speed of

Fig. 2. View of a Completed Section of Concrete Water Conduit, Los Angeles, Cal.

30 miles an hour can be attained in about half a minute. To meet similar conditions the Great Eastern Ry. has built a decapod tank engine, which has already been described in our columns. The dimensions of the Great Northern Ry. engine, which was designed by Mr. Ivatt, Locomotive Superintendent, are as follows:

Driving wheels	4 ft. 7½ ins.
Trailing wheels	3 " 7½ "
Driving wheelbase	17 " 6 "
Total wheelbase	25 " 2 "
Weight on drivers	147,840 lbs.
Weight, total	176,960 "
Cylinders (inside)	20 x 26 ins.
Boiler pressure	175 lbs.
Heating surface, tubes	1,302 sq. ft.
" " firebox	136 "
" " total	1,438 "
Grate area	24½ "
Water in side tanks	1,660 U. S. gals.
Coal in rear bunker	4 tons.